The American Iron and Steel Institute

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ARMY ORDNANCE

VOL. IV WASHINGTON, D. C., SEPTEMBER-OCTOBER, 1923 No. 20

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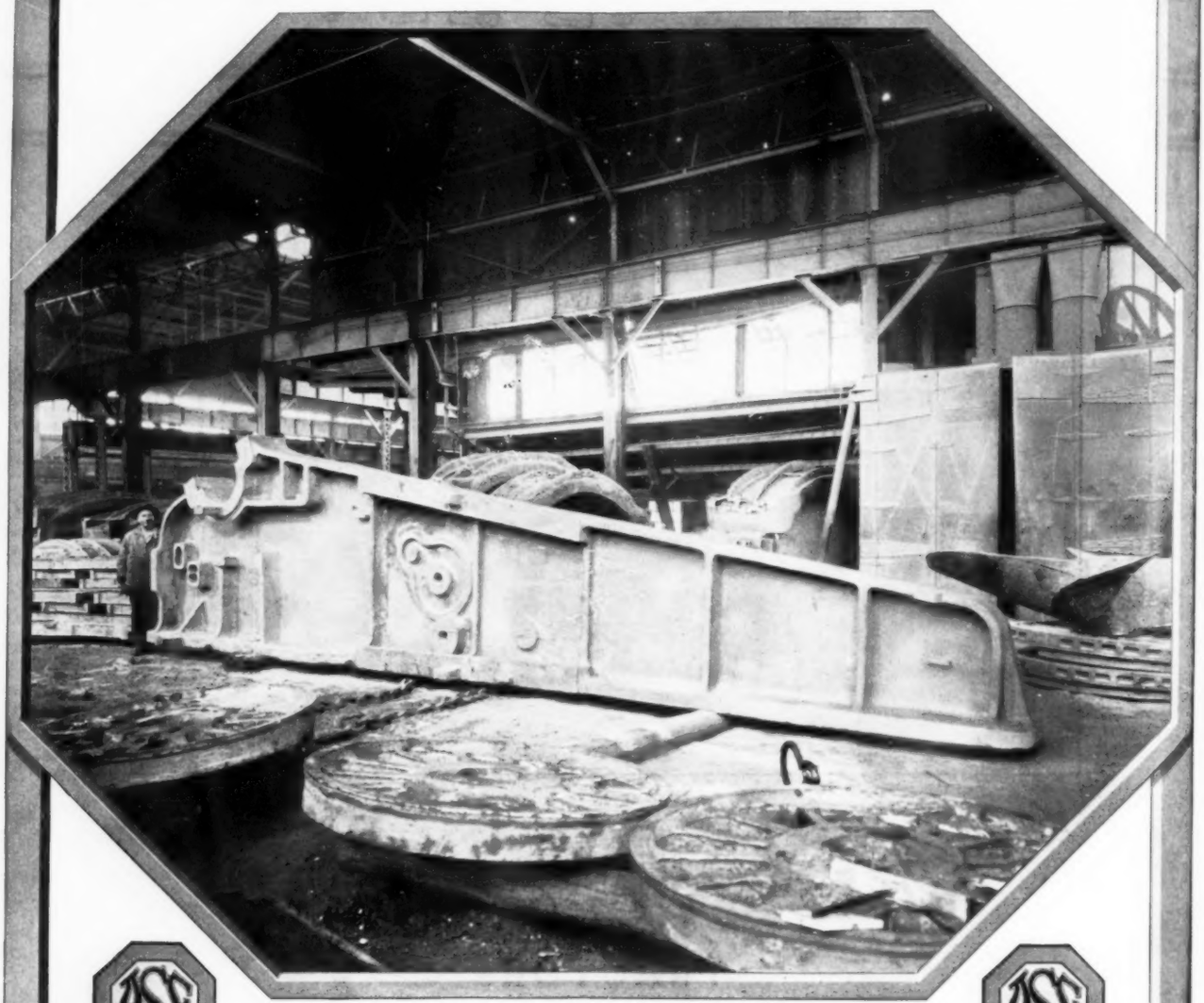
~THE·JOURNAL·OF·THE·ARMY·ORDNANCE·ASSOCIATION:~

Fifth Annual Meeting, Aberdeen Proving Grounds, October 26, 1923

AMERICAN STEEL FOUNDRIES



STEEL CASTINGS
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ARMY AND NAVY REQUIREMENTS

NEW YORK CHICAGO ST. LOUIS

The Fifth Annual Meeting *of the* ARMY ORDNANCE ASSOCIATION

The American Iron and Steel Institute Participating

will be held at The Aberdeen Proving Ground

Friday, October 26, 1923

This meeting of the Association is expected to be one of the largest ever held. An interesting program, which will be materially different from any hitherto given before the Association (see next page), is in preparation.

Arrangements have been made whereby members of the Army Ordnance Association may secure reduced fare to attend this meeting. Certificates have been furnished members which will enable them to purchase a round-trip ticket from the local agent at any point in the United States at the price of one and one-half single fare, except in the following territory: West of Chicago, Peoria and St. Louis, and east of Washington, Oregon and Nevada; southwest of St. Louis, including Texas, Arkansas, Oklahoma, Missouri (south of the Missouri River) and Louisiana (west of Mississippi River). Members living in Pacific Coast and other far western territory, not included within the above exceptions, may avail themselves of the all-year excursion fares affording 10 per cent reduction in fare to Washington or Baltimore.

The restrictions on the use of the certificate are:

It applies only to members of the Association and to dependent members of their immediate families; and is not transferable; the return must be made over the same route as that used in going; tickets may be purchased between the dates of October 23rd to 26th, inclusive, only, and must be used returning to reach the original starting point not later than midnight on November 1st; a minimum fare of $1 is required for all round-trip tickets.

All return tickets must be stamped at Aberdeen, or at Aberdeen Proving Ground, by the agent of the line over which members arrive (Baltimore and Ohio or Pennsylvania). Without this validation the ticket will not be honored on the return trip. Arrangements have been made to have agents of these roads at Aberdeen Proving Ground during the entire day until 6 p. m.

Members who are also members of the American Iron and Steel Institute and who wish to take advantage of the reduced fare to attend the New York meeting of the Institute on October 25th, should purchase their tickets to New York City, where they can secure round-trip tickets and reservations to Aberdeen through the office of the Secretary of the Iron and Steel Institute, 40 Rector St., New York City.

A special train of Pullman sleeping cars will leave the Pennsylvania Station, New York City, at 1.30 a. m., October 26th. It will be open to passengers at 10:00 p. m., October 25th, and will run direct to Aberdeen Proving Ground. Breakfast a la carte will be served by caterer at the Proving Ground. This train will leave the Proving Ground at 7:30 p. m., October 26th, and will arrive in New York at 11:30 p. m., in time for passengers to make connections with trains leaving New York at midnight. The fare on this train will be:

Railroad fare (round-trip)	$8.42
Lower berth (New York to Aberdeen)	3.00
Upper berth (New York to Aberdeen)	2.40
Chair (Aberdeen to New York)	1.13
Complete round trip, including lower berth to Aberdeen and chair returning to New York	12.55
Complete round trip, including upper berth to Aberdeen and chair returning to New York	11.95

Check covering the above should be made payable to and mailed to: Captain H. W. Churchill, Room 810, Army Building, 39 Whitehall Street, New York City. **All reservations must be made by October 24th.**

Train Service

(Trains as numbered will stop at Aberdeen, October 6. Consult timetable for possible change in time.)

Going:

Southbound—	Baltimore & Ohio		Pennsylvania	
	Train No.	Time	Train No.	Time
Leave Philadelphia	15	7:45 AM (Wayne Jnct.)	405	7:20 AM (Broad St.)
		8:00 AM (24th & Chestnut)	417	10:30 AM (Broad St.)
Arrive Aberdeen	15	9:26 AM	405	9:06 AM
			417	12:17 PM

Northbound—	Baltimore & Ohio		Pennsylvania	
	Train No.	Time	Train No.	Time
Leave Washington	4	7:15 AM	110	7:25 AM
			406	11:45 AM
Leave Baltimore	4	8:12 AM (Mt. Royal)	110	8:23 AM
			406	12:50 AM
Arrive Aberdeen	4	8:51 AM	110	9:05 AM
			406	1:46 PM

Returning:

Northbound—	Baltimore & Ohio		Pennsylvania	
	Train No.	Time	Train No.	Time
Leave Aberdeen	22	*5:07 PM	412	*4:52 PM
	20	9:05 PM	134	9:00 PM
Arrive Philadelphia	22	7:00 PM	412	6:55 PM
	20	10:40 PM	134	10:00 PM
Southbound—				
Leave Aberdeen	9	8:20 PM	413	6:29 PM
			131	9:15 PM
Arrive Baltimore	9	9:03 PM	413	7:10 PM
			131	9:56 PM
Arrive Washington	9	10:00 PM	413	**8:20 PM
			131	10:55 PM

Note: Trains marked * Passengers should leave Proving Ground on "Shop Train" at 4:39 P. M.

Passengers on train marked ** change in Baltimore for Washington.

Tentative Program—October 26, 1923

A.M.—9.45 Leave Aberdeen.
10.00 Leave Visitors' House.
10.15 Arrive Mulberry Point.
10.20 Fire one round with 16-inch Gun on Barbette Carriage.
10.30 Fire one round with 14-inch Gun, Railway Mount.
10.40 Fire 8-inch Howitzer, Model 1920, with split trail, and 155-mm. Gun on Self-propelled Mount, Mark IX.
10.50 Fire 3-inch Anti-aircraft Gun at target towed by airplane.
11.00 Drop two 600-pound Demolition Bombs, Mark I.
11.10 Destroy two balloons by Aircraft Machine Gun fire in the air.
11.20 Leave Mulberry Point.
11.30 Arrive Aviation Field; inspect bombs and equipment. Airship will take-off and lay down smoke screen.
12.00 Arrive at Visitors' House. Luncheon and brief addresses by Distinguished Guests.
P.M.—1.30 Leave Visitors' House.
1.35 Arrive at Main Front, where demonstrations of the following automotive matériel will be given:

Tanks:

Medium Tank, Model 1921;
Medium Tank, Model 1922;
Mark VIII Tank with Stroboscope;
Six-ton Tank;
Radio directed 6-ton Tank.

Tractors:

2½-ton Tractor, Model 1920, towing 75-mm. Gun and Limber;
Best "30" Tractor towing 4.7-inch Gun, Model 1906;
Holt T-35 Tractor towing ¾-ton Trailer;
Fordson Tractor with Hadfield-Penfield Adapter towing 75-mm. Gun.

Motor Carriages:

75-mm. Gun Motor Carriage, Mark VII;
75-mm. Gun Motor Carriage, Mark VI;
155-mm. Gun Motor Carriage, Model 1921 (Holt);
155-mm. Gun Motor Carriage, Model 1920 (Christie);
240-mm. Howitzer Motor Carriage, Mark III;
240-mm. Howitzer Motor Carriage (St. Chaumond);
Commercial (Christie types) of 75-mm. and 155-mm. Gun Motor Carriages.

Cross-Country Trucks:

6-wheeled Militor Truck;
6-wheeled Dodge Truck;
Nash Truck with Caterpillar adapters;
Mark VII Tractor Caisson.

Commercial Developments:

Roadless Mack Truck;
Christie-Mack Truck.

Reconnaissance Tractors:

Ford Reconnaissance Tractor.

2.30 Drop two 600-pound Demolition Bombs, Mark I.
2.40 Small Arms and Machine Gun Matériel.
2.55 The following rounds will be fired from the list of matériel shown below:
- 3 rounds 37-mm. High Explosive super-sensitive fuze against two layers of airplane linen four inches apart. The high explosive in these shells will have been replaced with black powder as a safety precaution.
- 3 rounds with 3-inch Anti-aircraft Gun, Model 1920, on trailer;
- 2 rounds with 4.7-inch Anti-aircraft Gun, Model 1920, on Christie Mount;
- 1 round with 155-mm. with G. P. F., Model 1920, on Self-propelled Mount, Mark IX;
- 1 round with 3.3-inch matériel to show yaw. Trail trajectory with 75-mm. Gun Shrapnel;
- 3 rounds with 75-mm. Gun, Model 1920, Split Trail;
- 2 rounds with 155-mm. G. P. F., using Du Pont "Nitrotite" containers.

3.35 Demonstration by battery of Sixth Field Artillery. The battery will maneuver to place, position and limber, and fire shrapnel at fixed targets; lay down smoke barrage followed by an advance of 6-ton tanks, using tank guns and machine guns against targets.
4.35 Visit Museum.
5.00 Meeting of the Army Ordnance Association, Administration Building, First Wing, Second Floor. Busses will run from Administration Building to Visitors' House between 5 and 6 o'clock.
6.00 Dinner will be served at Visitors' House. Moving pictures and night firing after dinner.
7.30 Train leaves for Aberdeen.

RESERVATION OF MEALS

Unless you mail this request for reservation of luncheon and dinner to the Proving Ground by Monday, October 22, 1923, no guarantee can be made that meals will be available for you. Since all food must be shipped from Baltimore by the caterer, it will be impossible to refund money for meals once ordered.

The Commanding Officer, Aberdeen Proving Ground, Maryland:

I desire to attend the Fifth Annual Meeting of the Army Ordnance Association to be held at the Proving Ground on Friday, October 26, 1923, and I request that you reserve luncheon and dinner for me on that day. I am enclosing my check for three dollars ($3.00) drawn to your order.

Please send Identification Badge and Meal Ticket to:

_____
(Member A. O. A.)

_____
(Address)

ARMY ORDNANCE

THE JOURNAL OF THE ARMY ORDNANCE ASSOCIATION

Pledged to Public Service in Effecting Industrial Preparedness for War as Our Strongest Guarantee of Peace

BENEDICT CROWELL, *President*
WILLIAM W. COLEMAN, *Vice-President*

DIRECTORS

To serve until October, 1925—
GUY E. TRIPP, SAMUEL MCROBERTS, WALDO C. BRYANT.

To serve until October, 1924—
ROBERT P. LAMONT, FRANK A. SCOTT, C. L. HARRISON.

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Election *of* Officers *of the* Army Ordnance Association

BENEDICT CROWELL

Hon. Benedict Crowell, former Assistant Secretary of War, was re-elected to his fifth term as President of the Army Ordnance Association at the annual election of the officers of the Association, held September 4, 1923.

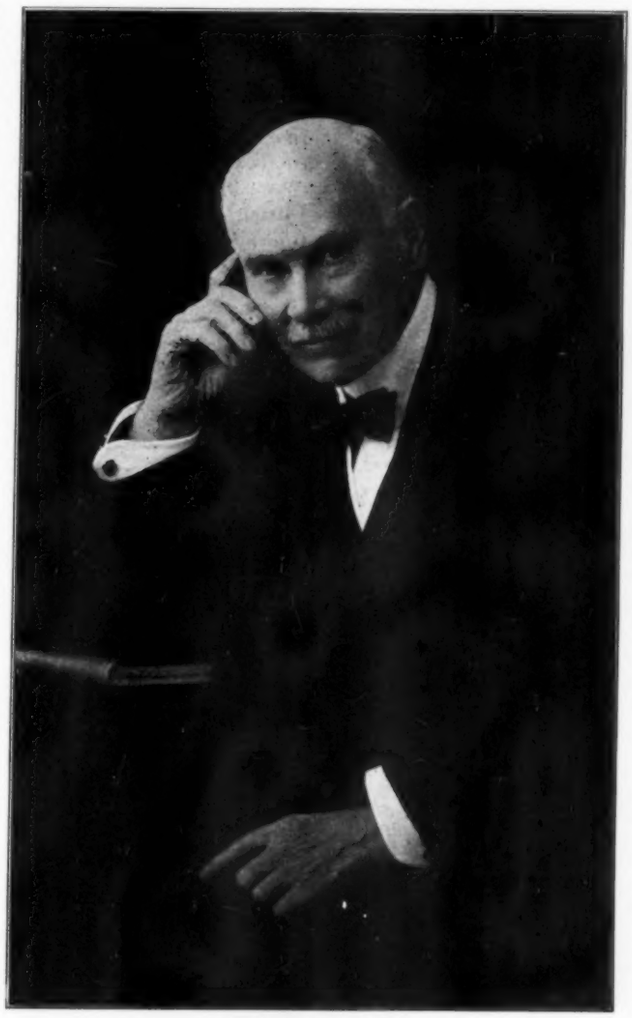
Mr. William W. Coleman, President of the Bucyrus Company, Milwaukee, Wisconsin, was re-elected Vice President, and the following Directors were chosen to serve until October, 1925: General Guy E. Tripp, Chairman of the Westinghouse Electric and Manufacturing Company; General Samuel McRoberts, President of the Metropolitan Trust Company, New York, and Mr. Waldo C. Bryant, President of the Bryant Electric Company, Bridgeport, Conn.

The American Iron and Steel Institute

By

HOWARD H. COOK

THE American Iron and Steel Institute was founded in 1908, having been incorporated under the laws of the State of New York on March 31st of that year. Judge Elbert H. Gary, in whose mind the idea of the Institute first originated, was elected its first President and has been annually re-elected to that office ever since, a fitting tribute to his wise and far-seeing administration.



ELBERT H. GARY
President, American Iron and Steel Institute
Chairman, United States Steel Corporation

The name of the Institute was adapted from that of The Iron and Steel Institute of London, England, which to some extent served as a model. The form of organization, however, differs quite materially. The British Institute, as it may be termed for convenience, is international in scope, and confines its attention to purely technical matters. The American Iron and Steel Institute, on the other hand, is limited as to its membership to residents of the United States, Canada and Mexico, while the scope of the organization is wider, so as to include in addition to purely technical matters, trade statistics and commercial, economic and social conditions affecting the industry.

The purposes for which the Institute was formed are set forth in the Constitution as follows: "The object of the Institute shall be to afford a means of communication between members of the iron and steel trades upon matters bearing upon their business interests." In other words, it seemed desirable to provide an organization to which the various individuals engaged in the iron and steel business might look for exact information upon matters affecting the industry. With this in view the functions of the Institute have developed along three main lines, technical, statistical and social.

The two general meetings of the members held each year provide an opportunity for the presentation of formal papers on the metallurgy of iron and steel; and the formal addresses of the President frequently cover a broader field. Annual statistics relating to the industry are gathered, compiled and published. Much attention has been given to questions of safety, sanitation and welfare.

At the time the American Iron and Steel Institute was formed there was already in existence an organization known as the American Iron and Steel Association, with offices in Philadelphia. This Association had been in existence for a very long time, originating as the American Iron Association in 1855. It was reorganized in 1864 as the American Iron and Steel Association, James M. Swank being Secretary and later General Manager. Under his direction, annual statistics of production were gathered, compiled and published together with other information taker from government reports and other sources. This information has been published regularly since 1872 under the name of the Annual Statistical Report of the American Iron and Steel Association. As both the Association and the Institute derived their membership from the same source, it seemed unnecessary to continue two organizations in existence and consequently on January 1, 1913, it was arranged that the American Iron and Steel Institute take over the work of the old Association. As Mr. Swank, who thus completed forty years of efficient service as Secretary and General Manager of the Association, expressed a desire to be relieved of the work on account of advanced age, the statistical work taken over from the Association continued to be carried on in Philadelphia, but as a separate department of the Institute, until the fall of 1915, when it was moved to New York and consolidated with the Institute offices there. The publications of the Association known as the Annual Statistical Report and the Directory of Iron and Steel Works have been continued by the In-

stitute, following in general, the same lines but with somewhat wider scope and rearrangement of the subject matter so as to be more convenient for reference.

The subject of welfare work early engaged the attention

JAMES A. FARRELL
Chairman, Committee on Arrangements, American Iron and Steel Institute
President, United States Steel Corporation

of the Directors and in May, 1911, a Committee on Welfare Work was appointed and the services of Dr. Thomas Darlington were secured as Secretary of the Welfare Committee. Dr. Darlington had previously been for six years Health Commissioner of New York City and had also conducted an extensive examination of the plants of the United States Steel Corporation from the point of view of sanitation and welfare. The reason for the formation of this committee was that although each company had done something in the way of safety and welfare work, and some companies had done much, there was still need of intelligent study of the situation with a view to determining from the experience already had by the various companies the best methods of handling the numerous problems involved, as well as the desirability of setting up standards which would serve as a guide to companies approaching the problems for the first time and inspire them with a desire to have the best obtainable.

Following the organization of this committee extensive examination was made of most of the steel plants of the country and of plants in other industries with the idea of putting on record what had actually been done by the companies under varying conditions. In this way a large amount of valuable information was gathered and made available for use in making specific suggestions to companies entering the field of welfare work or suggesting improvements for those who already had some experience.

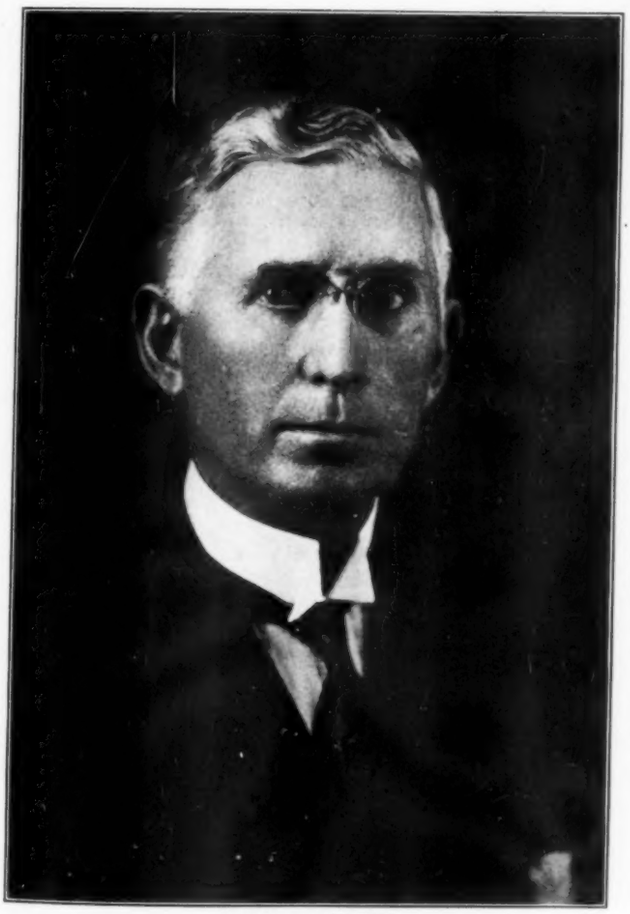
The wide scope of welfare activities can hardly be realized without some specific mention of the various lines along which the work proceeds. It includes not only devices for the prevention of accidents and arrangements for insuring the safety of working places, but also matters of sanitation and general welfare, such as, drinking-water supplies, baths and washing facilities, toilet arrangements, drainage and sewage disposal, disposition of garbage, etc., care of stables and animals, regulation of temperatures and ventilation, removal of dust, gases and fumes, first-aid organization, hospitals, trained nurses, and social workers and, under the heading of general welfare, matters relating to housing, gardens, club houses, playgrounds and recreation, as well as education and Americanization work, insurance, pensions, and opportunities for saving and investing.

As a means of presenting to the members of the Institute the information thus gathered, in a form convenient for use or for reference, a publication known as the *Monthly Bulletin* was organized and was first published in January, 1913. In general, each issue was devoted to a certain subject or subjects and gave details as to the work accomplished by various companies together with plans of the buildings erected and reproductions of photographs showing the results accomplished. This *Monthly Bulletin* continued to be published until October, 1917, when the stress of war work made it necessary to discontinue it. During the nearly five years that the *Bulletin* was published, many of the companies had developed highly organized departments devoted to welfare work and had acquired extended knowledge and experience. There was therefore no longer the same need for information on this subject and it was not deemed necessary to resume the publication of the *Bulletin* after the termination of the Great War. The valuable work of the committee in disseminating this information during the formative period should not, however, be overlooked. It doubtless had very great influence on the development of welfare projects and widened and extended their aim.

E. A. S. CLARKE
Secretary, American Iron and Steel Institute

On the entry of the United States into the war, the American Iron and Steel Institute at the request of the Government formed a Committee on Steel and Steel Products to mobilize the steel industry and to represent it in conferences with the governmental authorities. At a

later date subcommittees were appointed on Differentials, Steel Distribution, Sheet Steel, Ferro Alloys, Pig Iron, Iron Ore and Lake Transportation, Tubular Products, Tin Plate, Pig Tin, Scrap Iron and Steel, Wire Products, Wire Rope, Cold Rolled and Cold Drawn Steel, Malleable Castings, Cast Iron Pipe and on Traffic Conditions. The Committee with its various subcommittees acting in cooperation with the governmental authorities, the Secretary of War, Secretary of the Navy, Council of National Defense, War Trade Board, War Industries Board, etc., formed a complete system of control of the industry for war purposes covering the production, transportation and distribution of raw materials, the allocation of orders to the mills, the completion of orders in accordance with priority assignments, and the maintenance of production at the maximum possible under prevailing conditions of weather or transportation. In September, 1917, President Wilson fixed maximum prices on certain basic iron and steel commodities as agreed upon by the War Industries Board and the Committee on Steel and Steel Products. The committee at the request of the government recommended differentials and extras for intermediate and finished products in line with the maximum prices fixed for the basic commodities and this system, renewed every three months with such changes



JOHN A. TOPPING
Vice-President, American Iron and Steel Institute
Chairman, Republic Iron and Steel Company

as proved necessary in the meantime, prevented the sale of any iron and steel commodities at prices in excess of the maximum prices fixed and continued in force until December, 1918.

The work of the Institute through its Committee on Steel and Steel Products was without doubt one of the most important factors in the splendid accomplishments of the industry during the war in supplying the iron and steel necessary not only to the United States but to the principal nations associated in the Great War. As the members of the Committee and of its sub-committees were successful and experienced men actively engaged in the steel

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CHARLES M. SCHWAB
Vice-President, American Iron and Steel Institute
Chairman, Bethlehem Steel Corporation

business, the various problems were solved and questions promptly decided along lines of the best practice; thus eliminating error and delays and making possible the record outputs of steel, that were so essential and contributed so much to winning the war, as stated by King Albert of Belgium, Marshal Foch and M. Eugene Schneider of the Creusot Works in France in their addresses at the banquets of the Institute.

Many difficult problems were handled by the Committee. Because of the fact that many necessary raw materials, such as manganese ore, chrome ore, pig tin, etc., were normally imported in quantity from abroad, problems were world wide. The lack of shipping made it necessary to restrict such importations to the minimum, and to provide for this reduction by economy of use, by providing substitutes of lower grade or of other material, or by developing domestic supplies of inferior grade which could be worked up only at increased cost.

The Institute through its President rendered signal service to the country by the influence exerted by Judge Gary as a member of the Industrial Conference called by President Wilson to be held in Washington in 1919. Judge Gary's actions as a member of that conference are best stated by quoting the preamble and resolution unanimously adopted by the members of the Institute at their Sixteenth General Meeting on October 24, 1919.

"WHEREAS, Elbert H. Gary, President of the American Iron and Steel Institute, has rendered to the American people and the American iron and steel industries a service of inestimable value by his course as a representative of

the public in the Industrial Conference at Washington; therefore be it

Resolved, That the American Iron and Steel Institute, assembled in its semi-annual meeting, hereby records its unqualified approval of Mr. Gary's firm stand against any infringement of the rights of the individual in labor or in business, rights fundamental to American industrial supremacy as well as to American liberty; that it admires the vision and courage enabling him to discern and effectively oppose the radicalism injected into trade unionism by unscrupulous leaders, an element especially dangerous under present conditions, when world-wide unrest has created an opportunity for agitation aimed at the perpetuity of institutions under which our country has

WILLIS L. KING
Vice-President, American Iron and Steel Institute
Vice-President, Jones and Laughlin Steel Corporation

achieved its strength and our industries attained their efficiency and prosperity."

Two general meetings of the members are held each year, one in the spring, the other in the fall. The May meeting has always been held in New York while the October meeting has at times been held elsewhere, including Chicago, Pittsburgh, Cleveland, Cincinnati, St. Louis and Birmingham. At these meetings the first day has been devoted to the meeting proper, while excursions, or visits to industrial plants, when planned for in connection with the meeting, have been held on the following day or days. The morning and afternoon sessions of the General Meetings are devoted largely to the presentation of formal papers and to discussion of these papers. Many valuable papers on metallurgical subjects of current interest have been read. In some cases papers prepared by several authors form a connected series, continued from meeting to meeting, setting forth the experience of the authors on some particular phase of the metallurgical problem under consideration; the series as a whole covering the subject completely and forming the most up-to-date and authoritative literature on the subjects. In this way the subjects of the construction and operation of blast furnaces and the design and operation of steel furnaces and converters have been treated. In addition to strictly technical papers on the metallurgy of iron and steel, papers have been read on welfare topics, on the export trade, on the development of the steel industry in certain foreign countries, and on such commercial topics as contract obligations, extras, advertising, etc.

The proceedings at these meetings including the papers read, the discussions of the papers and the addresses delivered at the banquet held in the evening, are published annually in the Year Book of the American Iron and Steel Institute.

During the year 1911 steel manufacturers were invited to attend an international meeting of the leading iron and steel masters of Europe and America to be held at Brussels in July. Eleven prominent steel manufacturers, all of whom were directors of the American Iron and Steel Institute, accepted the invitation to attend as delegates. Arriving in England in advance of the meeting they were entertained by the British steel manufacturers from June 27 to June 30, the program including a visit to the Royal Agricultural Show at Norwich, a river trip upon the Thames, a view of the Royal Progress (Coronation of King George) and a banquet at the Savoy Hotel at which His Grace, the Duke of Devonshire, President of the British Iron and Steel Institute, presided.

Proceeding to Brussels, the international meeting was held on July 5 and 6, 1911. The Institute was honored by having its President, Judge Gary, made Chairman of the meeting; and his splendid address and past record in bringing about cooperation in the steel industry of the United States resulted in the unanimous expression on the part of the delegates of a desire for world cooperation. It was left to Judge Gary as Chairman of a special committee to call another International Conference at such time as he should deem fitting; and it is hoped that conditions in Europe will soon be so restored as to permit such a meeting to be held with representatives of all European steel manufacturers in attendance.

A banquet at which Mr. Adolphe Greiner of the Societe John Cockerill, the most important Belgian steel company, presided was given in honor of the delegates assembled. The Institute was further honored when King Albert received the members of the International Meeting in special audience at the palace. The entertainment closed with an all-day excursion to the well-known Grottos of Han.

The social side of the Institute meetings has developed an importance perhaps not clearly foreseen at the outset. The meetings themselves, and particularly the banquets held in the evening at the close of the sessions, afford an opportunity for members to meet old acquaintances and form new friendships and furthermore to meet the many distinguished guests who have from time to time added to the pleasure of the occasion. After-dinner addresses of great interest and importance have been delivered by men prominent in the industry and by guests of the Institute distinguished in other lines of endeavor.

Among the many prominent guests from overseas who have honored the banquets of the Institute by their presence are King Albert of Belgium, Marshal Foch, Field Marshal Earl French, Prince Gelasio Caetani, the Royal Italian Ambassador, M. Eugene Schneider and M. Marcel Knecht. Representing the Army and Navy of the United States have been General Pershing, Major Generals Goethals and Glenn, and Admirals Fletcher and Vogelgesang; and among prominent American business men and engineers Messrs. George W. Perkins, Dwight W. Morrow, Percival Roberts, W. D. Guthrie, Edward N. Hurley, Charles P. Taft, Nicholas Longworth, Robert S. Brookings, James H. Hoyt, Professor Henry M. Howe, Captain

Robert W. Hunt, Julian Kennedy, Charles P. Perin and Charles F. Rand. The leaders of the steel industry have all from time to time spoken at the banquets on the important topics of the time, and the members and their personal guests have always shown a keen appreciation of the importance and value of these functions.

The most recent and perhaps one of the most noteworthy accomplishments of the Institute in time of peace, has been its bringing about the abolition of the twelve-hour day.

On May 18, 1922, President Harding invited over forty representative members of the American Iron and Steel Institute to dine with him at the White House for the purpose of discussing the possibility of eliminating the twelve-hour work day in the iron and steel industry. The President expressed a feeling that there was a well defined and growing sentiment throughout the country against the twelve-hour day and in favor of its abolishment and requested that it be eliminated if at all possible. The matter was discussed at length and it was finally unanimously agreed by those present that the President of the American Iron and Steel Institute should appoint a committee to make a careful investigation, ascertain the facts applicable and report their recommendations to the iron and steel industry.

At the annual meeting of the Institute held on May 26, 1922, Judge Gary reported these facts to the Institute and appointed a Committee on the Proposed Total Elimination of the Twelve-hour Day. This committee was composed of nine members, all Directors of the Institute, as follows:

Elbert H. Gary, Chairman, United States Steel Corporation;

L. E. Block, Chairman, Inland Steel Company;

James A. Burden, President, Burden Iron Company;

James A. Campbell, President, Youngstown Sheet and Tube Company;

A. C. Dinkey, President, Midvale Steel and Ordnance Company;

James A. Farrell, President, United States Steel Corporation;

Eugene G. Grace, President, Bethlehem Steel Corporation;

Willis L. King, Vice-President, Jones & Laughlin Steel Corporation;

John A. Topping, Chairman, Republic Iron and Steel Company.

This committee made a very thorough and careful investigation of the subject. A subcommittee was appointed to give special attention to the subject matter and to secure data. Various experts were employed to make a thorough local and personal examination in regard to all the facts which were applicable. When this preliminary work had been accomplished the general committee gave careful consideration to the whole subject matter and discussed it very thoroughly.

At the Annual Meeting of the American Iron and Steel Institute, May 25, 1923, Judge Gary, Chairman of the committee, presented a preliminary report of the committee which was accepted and approved by a unanimous vote of those present. The report, after pointing out that the alleged hardships and ill effects of the twelve-hour day had been misrepresented by those unfamiliar with the industry and did not in fact exist, stated that in order to substitute three shifts of eight hours for two shifts of twelve hours there would probably be needed 60,000 additional employees, and it was estimated that through increased wages the cost of production would be increased on the average about 15 per cent. The report further stated that under the conditions then existing (May, 1923) it would be impossible to immediately obtain a sufficient number of men to allow of this change. The gist of the report is given in the last paragraph which reads as follows:

"There was a consistent, persistent and successful effort during the time labor was more plentiful to reduce the numbers of men employed twelve hours per day. Although the percentages fluctuated, depending upon circumstances, the percentage was gradually reduced, as stated publicly. If labor should become sufficient to permit it, the members of this committee would favor entirely abolishing the twelve-hour day, provided the purchasing public would be satisfied with selling prices that justified it, and provided further, that the employees would consent and that industry generally, including the farmers, would approve."

W. J. FILBERT
Treasurer, American Iron and Steel Institute
Comptroller, United States Steel Corporation

After consideration of this report, President Harding, in a letter dated June 18, 1923, expressed his regret that no conclusive arrangement was proposed in the report for eliminating the twelve-hour day, and requested the steel industry "to consider giving an undertaking that before there shall be any reduction in the staff or employees of the industry through any recession of demand for steel products, or at any time when there is a surplus of labor available, that then the change should be made from two shifts to the three-shift basis." In response to this request, a meeting of the Directors was immediately called, and the Directors of the American Iron and Steel Institute under date of June 27, 1923, gave the following undertaking: "Undoubtedly there is a strong sentiment throughout the country in favor of eliminating the twelve-hour day, and this we do not underestimate. On account of this sentiment, and especially because it is in accordance with your own expressed views, we are determined to exert every effort at our command to secure in the iron and steel industry of this country a total abolition of the twelve-hour day at the earliest time practicable." It was pointed out that time would be required to effect the change as a large addition to the numbers of workmen would be

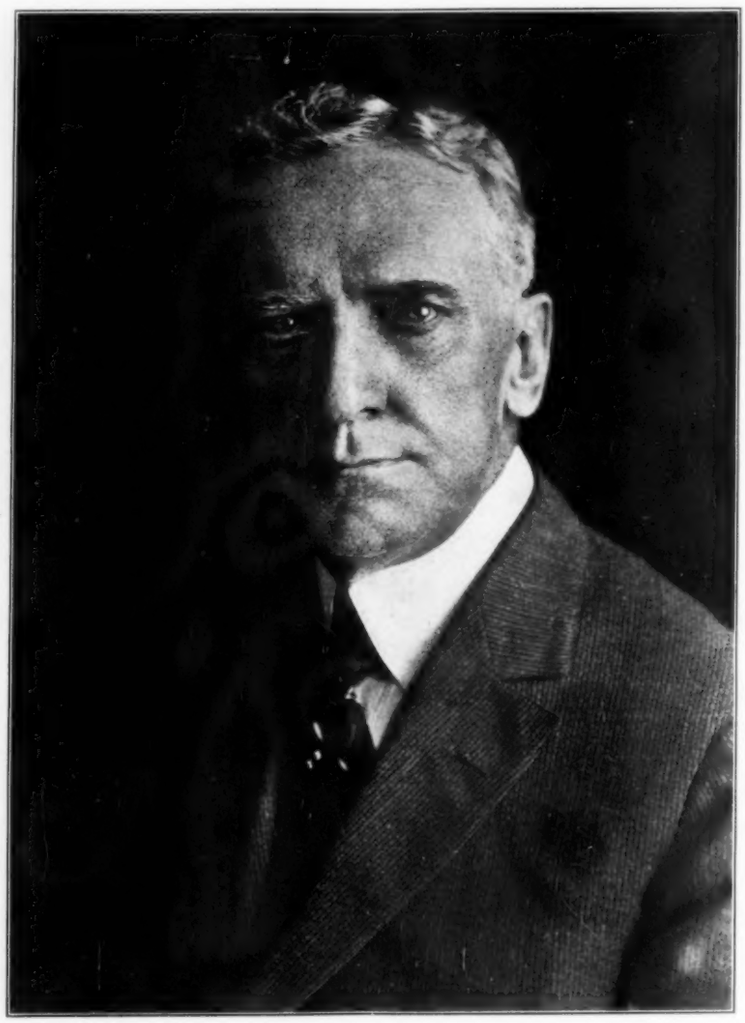
(*Continued on Page 76*)

Super-Power As An Aid to National Defense

By

GEN. GUY E. TRIPP

THE immense demand for supplies of every description that arose during the World War acted as a gigantic test of our productive facilities. It was just such a test as an engineer applies to a newly designed machine — our industrial and transportation mechanism was overloaded almost to the breaking point, thereby disclosing many merits and many serious defects. Ordinarily, the chief benefits of this test would have been lost to us because of the difficulty in compiling and interpreting so vast a mass of facts. But fortunately, the War Industries Board was in a position to follow every step of this unusual experiment and has left records of the utmost value for our future guidance.



GENERAL GUY E. TRIPP
Director, Army Ordnance Association
Chairman, Westinghouse Electric and Manufacturing Company

One of the weaknesses thus brought to light was the inadequacy of our usual methods of generating and transmitting electric power. Very shortly after war production got well under way, power shortages developed in the industrial districts of New England, New Jersey, eastern and western Pennsylvania, and Niagara Falls. Studies were made by army engineers serving the War Industries Board, and it was soon apparent that the difficulty was one of distribution rather than of generating capacity. Thus, though northern New Jersey was sorely in need of more power, New York City, a few miles away, had an ample surplus. In New England, a parallel situation existed. Boston had a surplus, but the surrounding industrial regions demanded more than the stations supplying them could provide. In the coal regions of western Pennsylvania and Ohio there was a real shortage of power, but this could have been greatly alleviated if the available power could have been applied where it was most needed.

The remedy for this condition of affairs was obvious. If the various individual electric systems could have been connected together into large unified systems, thus making it possible to draw on surpluses at any points for deficiences elsewhere, most of the districts would have had sufficient power to meet their requirements without additional generating units. Steps were taken to effect some of these interconnections but the armistice made government action in this direction unnecessary.

Another problem of a somewhat different order arose in connection with the large-scale production of nitrates, poison gas, powder, phosphorus, and other electrochemical products needing large blocks of power for their manufacture. Although the total generating capacity of the country exceeded 30,000,000 horsepower, nowhere could the War Industries Board find an adequate supply that could be concentrated where needed. Here again the ability to draw upon extensive electric systems would have solved the problem.

Finally, an even more serious defect in our system of power distribution was all too well known by our military

authorities. This was the fact that a very large part of our essential war materials was being made in the northeastern states and especially in the vicinity of New York City, Boston, and Philadelphia.

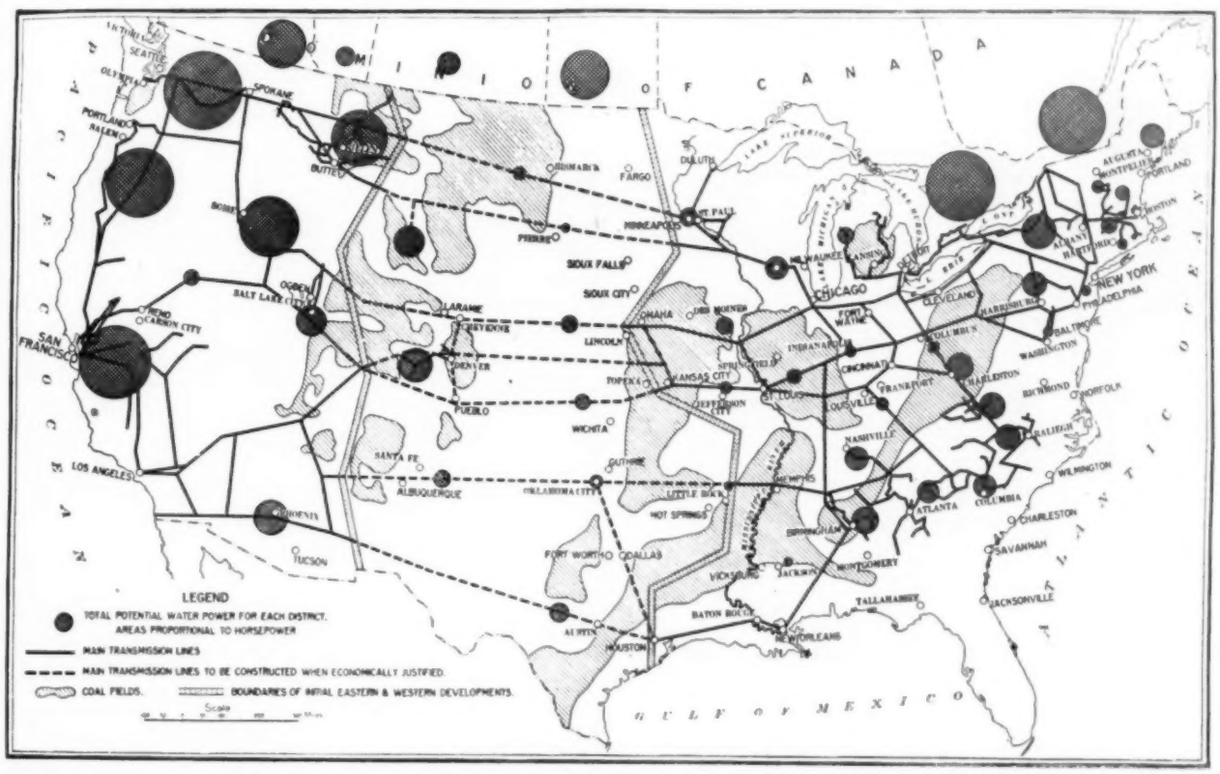
"This region," declares General R. L. Bullard, "is the vital region of our whole country. It is vital because it contains all that is essential to keep the country alive, agriculture, industries, wealth, population, and lines of communication. It is the region, therefore, which must be the final objective of any power that should ever make war against us. It is also our most vulnerable region."

No military education is needed to understand that the bulk of our war supplies for the next war should be produced behind our natural defense lines, the Allegheny and the Rocky mountains. This cannot be done, however, unless industry is well developed within this area; and this, in turn depends upon the existence of an ample supply of power, which must necessarily be supplied by large electric systems.

These lessons taught by the war confirm the conclusions that had been reached by electrical engineers before the war; namely, that isolated and relatively small electric power systems no longer suffice to meet the power demands of the nation, and that large unified systems, covering wide areas and receiving power from steam and water power plants of maximum capacity and highest efficiency, are essential if American progress is to continue at its present rate.

These conclusions have been embodied in the so-called "super-power" plan, which has been endorsed in its main outlines by the great majority of American engineers and public utility officials. According to this plan two "super-power" systems—one covering the area east of the Mississippi and the other that west of the Rockies—are projected, to be formed through the interconnection of existing power systems with new construction wherever necessary. Into these systems will pour energy from all of the water powers within the area covered, supplemented by large steam plants at convenient locations, such as in the coal regions and along the seacoast. From these systems electric power will be drawn for all purposes. Ultimately it is expected that these two systems will themselves be interconnected so as to form a single system.

Inasmuch as a super-power system provides means for distributing the maximum amount of power to the largest number of people at the lowest cost, there is every reason to expect that at least the eastern and western systems will become realities within the next decade or two. In fact, the process of intereonneeting the various individual electric light and power systems is already under way, and super-power systems on a small scale are being formed in all parts of the country.



Map of a suggested super-power system for the United States, showing also the coal fields and the potential water power of the United States and Canada. The lines shown represent the main transmission trunks; the secondary distributing lines, which will practically cover the entire country, are omitted. From a military standpoint, one of the most important features of the system is the power it supplies to the area around Saint Louis which is the most thoroughly protected portion of the country, and is an ideal location for industries producing special war supplies.

With a super-power system covering at least the area east of the Mississippi in existence, the three chief power problems of the last war would be solved. But additional advantages would be secured.

The general use of water power and the burning of fuel in plants of the highest efficiency only would greatly decrease our need for coal. This would reduce the necessary man power at the mines, lift a heavy burden from our transportation system, and eliminate many difficulties incident to the distribution of coal.

Our transportation facilities would also be relieved because much of the coal consumed in generating power would be burned at the mines and would need no transportation, while the greater part of the remainder would be

delivered to a limited number of power plants at easily reached points where facilities for handling and storing coal in bulk would be provided. The electrification of the more important railroads would be a further step in the direction of improved efficiency and reduced coal consumption.

The man power needed to carry on essential work in all industries would be reduced through the general use of electrically operated machinery.

The power supplied by a super-power system would be fairly safe from interruption from strikes, violence, or enemy activities because water-power plants are independent of fuel supplies, can be operated by small forces, and are easily guarded; damaged transmission lines can be readily repaired; and the destruction of several of the generating plants of the super-power system, together with considerable sections of transmission network, would not necessarily put the entire system out of commission.

Special war industries could be established in the shortest possible time, placed in the most favorable localities, and operated by the minimum number of people.

It is impossible to overestimate the military value of these factors. In fact, a nation-wide super-power system, together with our natural resources and topographical advantages, would render the United States well-nigh unconquerable. Thus, the electric power system that best suits the needs of peaceful progress is also one of the strongest elements of our national defense.

Army engineers will have more than an academic interest in the super-power plan. They will also play an important part in its execution. Due to their work in improving river navigation and controlling floods, they are constantly concerned with hydraulic undertakings. If they are familiar with the super-power plan and accept its military importance, they will naturally coordinate their own work with water-power development, and will consider each development in its relation to the nation-wide plan and not to local conditions only.

They can also assist in another way. Though the super-power plan is practical and desirable, both technically and economically, and is already in the process of development, it will not be realized in its entirety until public opinion is fully in favor of it. For very excellent reasons, both our people and our lawmakers hold the opinions of Army engineers in the highest respect. If, therefore, the Army engineers advocate the super-power plan, its general acceptance will be measurably expedited.

NOTE: A comprehensive description of the single super-power system is given in Mr. Frank G. Baum's *Atlas of U. S. A. Electric Power Industry*, published by the McGraw-Hill Book Company, New York City; and a brief account of it is contained in an article on "The Electrification of North America," by the writer, in *World's Work*, September, 1923. Reference should also be made to "The Power Situation During the War," by Col. Chas. Keller, U. S. A., War Department Document No. 1039, published in 1921; and to "A Super-Power System for the Region Between Boston and Washington," by Mr. W. S. Murray and others, Department of the Interior, Professional Paper No. 123.

The American Iron and Steel Institute

(*Continued from Page 73*)

required and many adjustments, some of them complicated and difficult, would have to be made, but that there would be no undue delay.

Preparation of plans for putting the new system in effect were begun at once inasmuch as there seemed to be an opportunity of obtaining additional workmen. During the last week in July many conferences were held in New York and other cities for the purpose of discussing the best methods to be adopted, the most important being a meeting of the presidents of the subsidiary companies of the United States Steel Corporation on Thursday, July 26th, and meetings of the Directors of the American Iron and Steel Institute on July 27 and August 2. At the conclusion of the meeting of the Directors of the Institute, Judge Gary made the following statement:

"Following correspondence between President Harding and the Steel Institute, and as a result of the most painstaking investigation, manufacturers of iron and steel, representing substantially the entire industry of this country, will now begin the total elimination of the twelve-hour day and will progress as rapidly as the supply of labor will permit. It is impossible to say when the changes will be completed. It will depend upon labor conditions at respective plants. There will be no unnecessary delay.

"Where the hours of employees connected with continuous processes are reduced from twelve to eight hours, their wage rates will be so adjusted as to afford earnings equivalent to a twenty-five per cent increase in hourly and base rates. All other workmen will be on ten hours or less and their present hourly and base rates will be continued; but whenever it is practicable, by promotions or changes in position, the daily earnings will be accordingly adjusted."

The Carnegie Steel Company, largest subsidiary of the United States Steel Corporation and the most important single factor in the industry, began to put this new system into effect on August 16. Other subsidiaries of the Steel Corporation took similar action, the Illinois Steel Company commencing August 13, 1923. The other large steel companies have also begun to eliminate the twelve-hour day and expect to carry the work to completion as soon as laborers can be obtained to operate the additional shift.

The Institute is constantly alert to bring about the proper solution of the many important problems which affect the steel industry. It functions carefully, conservatively and deliberately. Its record of sound accomplishment is at once its pride and its best recommendation.

Examination of Steel by the X-ray Spectrometer

By

HERMANN H. ZORNIG*

A study of the available literature dealing with the crystal structure of the constituents and structures recognized to exist in the iron-carbon alloys shows that most of our knowledge on the subject is based on separate experiments conducted from time to time in different laboratories by different investigators using very often quite different apparatus. Conclusions have sometimes been based upon small differences in measurements, which measurements were not easy to make, and which were subject to errors which are difficult to correct. It appears that additional information regarding the crystal structure of the transformation stages in the iron-carbon alloys and regarding the manner in which the transformations take place may be obtained by series of X-ray diffraction patterns produced by specimens differing from each other by changes, as nearly as possible, in but one variable; the photographs of the diffraction patterns to be taken under uniform conditions, in the same apparatus, and in a manner which will eliminate as many of the known sources of possible error as is practicable. The research program of the Laboratories of the Watertown Arsenal includes the production of a number of such series of diffraction patterns. The attempt of the writer, working in these laboratories, to produce one such series is herein described. This series is intended to show the relations existing between crystal structure and microstructure in a hyper-eutectoid plain carbon steel.

Description of Apparatus

The X-ray spectrometer used in these experiments was the standard X-ray Diffraction Apparatus manufactured by the General Electric Company, and described by Wheeler P. Davey, in the *Journal of the Optical Society of America*, Vol. V, No. 6, Nov., 1921. In order to adapt this apparatus to take specimens of the shape found to be best suited to this work, one of the cassettes was slightly modified as described later.

Description of Specimens

The use of individual crystals as specimens was obviously impossible so there remained three general forms of specimens to choose from, namely, the powdered material mounted in tubes or in films of amorphous materials (3 and 4), the material drawn or otherwise formed into fine wire, (3) or narrow flat surfaces of the material such as the edges of ribbons.[1] Of these, the last form was chosen because it permitted the use of specimens which could be easily heat treated and in which the surface layer of the diffracting crystals could readily be examined microscopically.

The specimens were prepared from a piece of 1.50-inch (3.805 cm.) diameter, round, hot rolled bar stock. This was carefully forged down into several strips about 0.187 inch (0.475 cm.) by 0.875 inch (2.22 cm.) by 14 inches (35.5 cm.) in size. These strips were reduced by grinding to a section of 0.085 inch (0.215 cm.) by 0.75 inch (1.9 cm.), care being taken to remove about the same amount of material from opposite sides. They were then cut into lengths of about 1.25 inch (3.17 cm.).

This method, it is believed, insures uniformity in the chemical composition of all the specimens to well within the limits required for this work.

Drillings, taken from the tonghold (about 1 inch [2.54 cm.] square in section) which had been left on one of the forged strips, were analyzed to obtain the chemical composition of the specimens. This analysis is given in Table I.

Table I

Chemical Composition of Specimens.

Constituent	Per cent by Weight	Atomic per cent	Remarks
Carbon	1.110	4.96	
Manganese	0.330	0.32	
Silicon	0.200	0.38	
Sulphur	0.021	0.04	
Phosphorus	0.008	0.02	
Nickel	0.350	0.30	
Chromium	0.090	0.09	
Iron	97.891	93.89	By difference
Iron Carbide (Fe_3C.)	16.6		Calculated, assuming all the carbon present is combined with iron in the form of Fe_3C.

The specimens were next heat treated as shown in Table II.

To prevent, as much as possible, the decarbonizing of the surface, all specimens while being heated to the 800° and 950° temperatures were immersed in a bath of "Meltite" contained in a clay assayer's crucible. All specimens, except No. 1 and No. 2, were heated to the 800° and 950° temperature together in the same furnace.

After heat treatment the diffracting surface of each specimen was polished, etched, and examined microscopically. In every case a slight amount of surface decarburization was found. The decarburized surface layer was carefully removed from the top and sides of the specimen by hand, using a fine file, or where the specimens were very hard, by a slow-moving grindstone well covered with water. The removal of surface metal was in each case continued until the whole of the surface showed, after polishing and etching, a uniform structure upon microscopic examination. The

* This paper was submitted in partial fulfillment of the requirements for the degree of Master of Science from the Massachusetts Institute of Technology, 1923, under the direction of the Faculty Board of the Ordnance School at Watertown Arsenal.

1 D. W. McKeehan: Jour. Franklin Inst., vol. 12 (1922), 231.

Table II.

Heat Treatment of Specimens.

Specimen Number	First Treatment Heated to	First Treatment Held at Temperature	First Treatment How Cooled	Second Treatment Heated to	Second Treatment Held at Temperature	Second Treatment How Cooled	Third Treatment Heated to	Third Treatment Held at Temperature	Third Treatment How Cooled
1	950° C.	30 Min.	Furnace*						
2	950° C.	30 Min.	Mercury*						
3	950° C.	30 Min.	Oil*	800° C.	10 Min	Water*			
4	950° C.	30 Min.	Oil*	800° C.	10 Min	Oil*			
5	950° C.	30 Min.	Oil*	800° C.	10 Min	Water*	185° C.	30 Min.	Air*
6	950° C.	30 Min.	Oil*	800° C.	10 Min	Water*	275° C.	30 Min.	Air*
7	950° C.	30 Min.	Oil*	800° C.	10 Min.	Water*	375° C.	30 Min.	Air*
8	950° C.	30 Min.	Oil*	800° C.	10 Min.	Water*	475° C.	30 Min.	Air*
9	950° C.	30 Min.	Oil*	800° C.	10 Min.	Water*	575° C.	30 Min.	Air*
10	950° C.	30 Min.	Oil*	800° C.	10 Min.	Water*	675° C.	30 Min.	Air*

* Details of cooling methods were as follows:
Furnace—Cooled in the furnace with power shut off.
Mercury—Quenched in mercury bath surrounded by ice and brine bath.
Water—Quenched in water bath at room temperature.
Oil—Quenched in bath of "Houghton's No. 2 Soluble Quenching Oil" at room temperature.
Air—Cooled in the atmosphere while supported on a piece of asbestos board.

width of the diffracting surfaces was at this time brought to 0.7 m/m + 0.05 m/m.

Photo-micrographs were made of the prepared surfaces at magnifications of 100 and 2,000 diameters. The etching reagent used in all cases was a 2 per cent solution of nitric acid in alcohol. The photo-micrographs taken at a magnification of 2,000 diameters are intended to show the details of the structure existing in the specimen.

Method of Taking X-ray Diffraction Patterns

For the taking of the X-ray diffraction patterns the specimens were mounted, two at a time, in the modified cassette as shown in Figure 1. The modification of the cassette consisted only of the addition of the special specimen holder which is shown in the photograph and whose operation and construction is so obvious as to need no further description. In mounting the specimen in the holder, care was taken to line up accurately the diffracting surfaces especially with respect to their tops and the edges away from the source of the X-rays. In this way it is possible to produce on the same photographic film under identical conditions the diffraction patterns of two specimens whose crystal structures are to be compared.

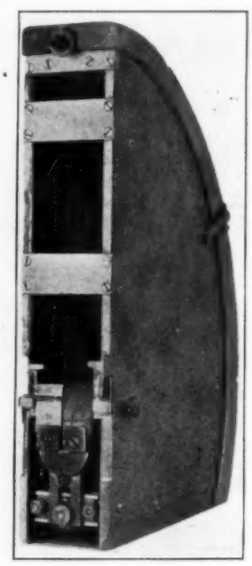


Fig. 1.

The standard exposure selected was 1,000 milli-ampere hours.[2] This exposure was not obtained in all cases, mainly because of trouble with the diffraction apparatus.

In taking the X-ray diffraction patterns, specimen No. 1 was used as the "control" or standard comparison specimen. It was selected for this purpose because it has the typical structure of annealed material. In it, according to accepted theories, all, or nearly all, the carbon is combined with iron in the form of the carbide, Fe_3C, and the crystals of the carbide and the remaining iron are in equilibrium. This specimen was "standardized" by comparing its diffraction pattern with that from a specimen of annealed electrolytic iron whose composition as determined by chemical analysis was:

Carbon	0.02 per cent
Manganese	Nil
Silicon	Nil
Sulphur	0.003 per cent
Phosphorus	0.003 per cent

The diffraction patterns of the remaining specimens were each taken on the same photographic film with the pattern of the annealed specimen.

Data Obtained

The X-ray diffraction patterns taken are listed in Table III, and are shown, as well as it was found possible to reproduce them by photographic means, in Figs. 3 and 4. The photo-micrographs showing the structure of the specimens which produced the diffraction patterns are also shown in Fig. 2.

Table III.

Showing arrangement of X-ray diffraction patterns.

Film No.	Specimen No.	Description	Approximate exposure in milli-ampere-hours
1	A	Electrolytic Iron, not annealed	
	B	Electrolytic Iron, annealed	1000
2	B	Electrolytic Iron, annealed	
	1	1.11 Carbon Steel, annealed	1000
3	1	1.11 Carbon Steel, annealed	
	2	1.11 Carbon Steel, martensitic with trace of austenitic	1000
4	1	1.11 Carbon Steel, annealed	
	3	1.11 Carbon Steel, martensitic	980
5	1	1.11 Carbon Steel, annealed	
	4	1.11 Carbon Steel, martensitic	1000
6	1	1.11 Carbon Steel, annealed	
	5	1.11 Carbon Steel, martensitic with trace of troostitic	980
7	1	1.11 Carbon Steel, annealed	
	6	1.11 Carbon Steel, troostitic with trace of martensitic	925
8	1	1.11 Carbon Steel, annealed	
	7	1.11 Carbon Steel, troostitic	1000
9	1	1.11 Carbon Steel, annealed	
	8	1.11 Carbon Steel, troostitic with trace of sorbitic	890
10	1	1.11 Carbon Steel, annealed	
	9	1.11 Carbon Steel, sorbitic	850
	10	1.11 Carbon Steel, annealed	
	10	1.11 Carbon Steel, sorbitic showing beginning of spheroidizing of cementite.	1000

Where it is thought necessary the lines in the several diffraction patterns have been marked to indicate the part of the crystal structure which produced them. The lines produced by the iron crystals have been identified by comparing the interplaner distances computed from measurement of the diffraction patterns with the inter-

[2] In the Watertown Arsenal laboratory exposures are, for the sake of convenience, expressed in milli-ampere hours. The exposure is found by multiplying the average tube current in milli-amperes by the length of exposure in hours.

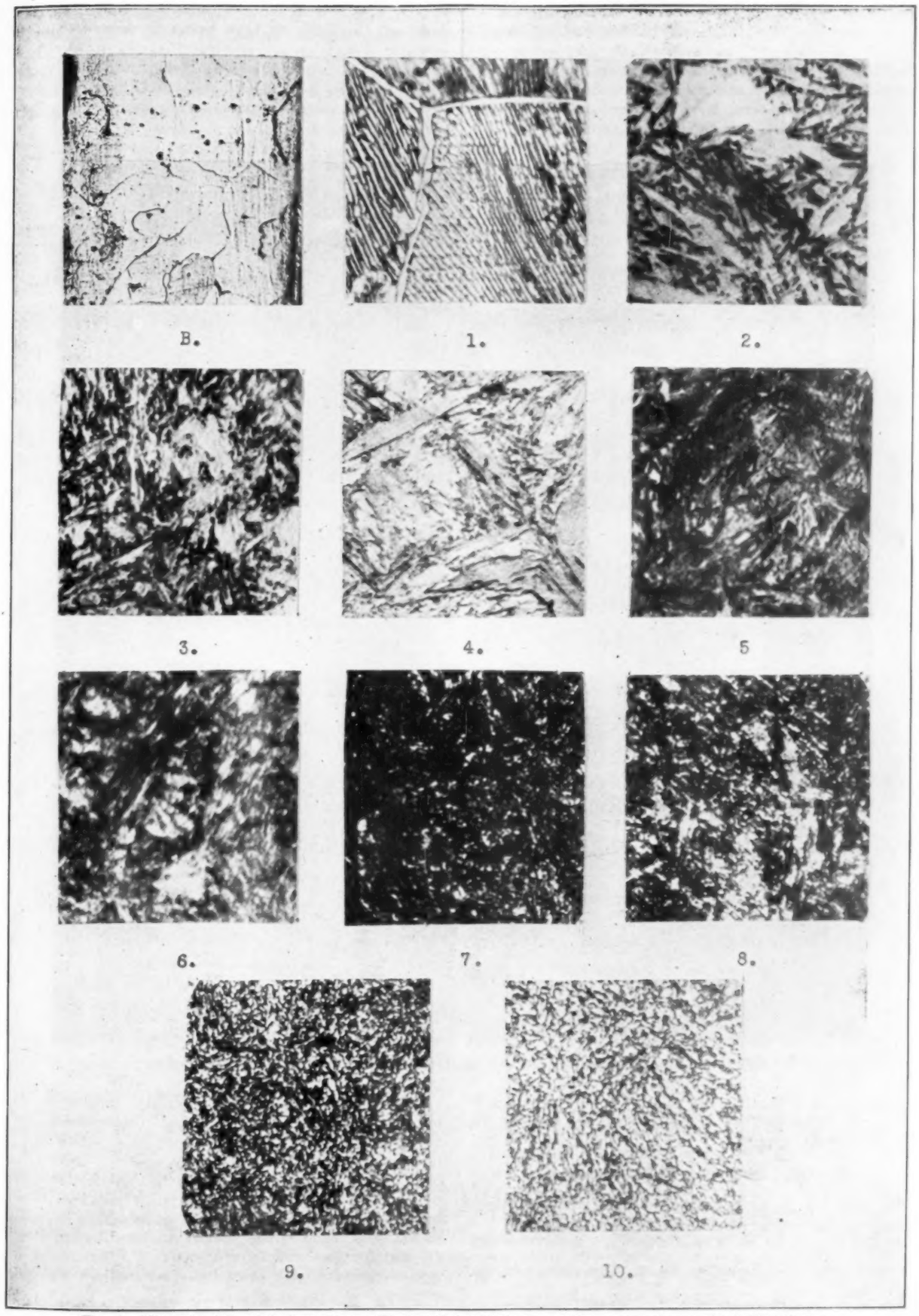


Fig. 2. Micro-structure of test specimens (B magnified 100 times; specimens 1 to 10 magnified 2000 times)

planer distances calculated from the space lattice of α iron as determined by Hull,[3] and that of γ iron as determined by Westgren.[4] The iron carbide lines have been identified by comparison of their location on the diffraction pattern with the location of the lines in the iron carbide pattern as reported by Westgren[5] and Phragmen and with other data regarding the iron carbide pattern which has been obtained at the Watertown Arsenal in connection with another research, but this has not yet been published.

trolyte, and specimen B contains the metal annealed. Some of the lines of both patterns show dense spots which on close examination appear to be very flat ellipses. Such spots have been shown by McKeehan[6] to be images of the source of X-rays produced by the presence, in the specimens, of large crystals with uniformly oriented lattices.

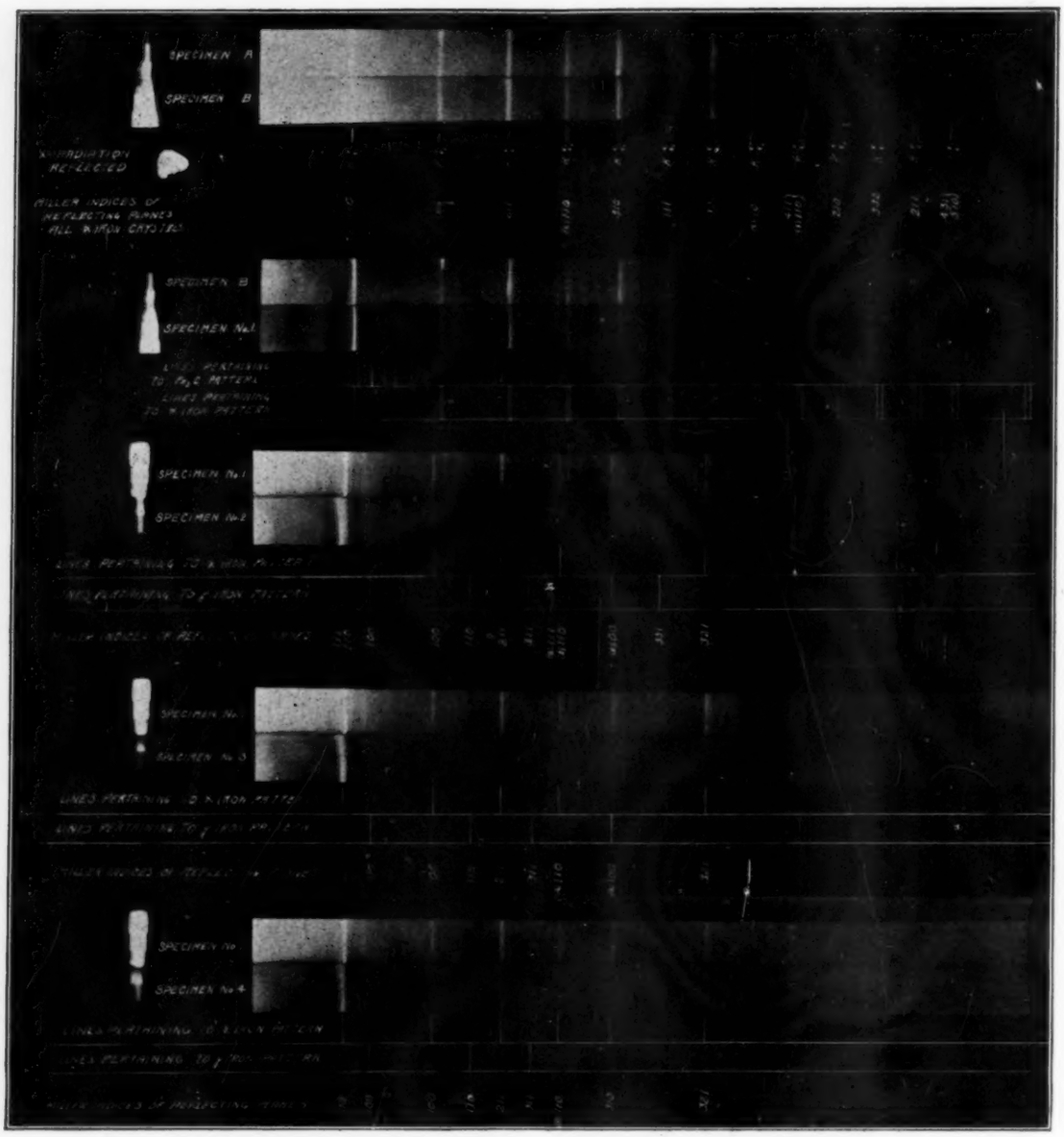


Fig. 3. Photographic reproductions of diffraction patterns (Films Nos. 1, 2, 3, 4, and 5)

Discussion of Data

On film No. 1 are produced the diffraction patterns from two specimens of electrolytic iron. Specimen A contains the metal as it was deposited from the electrolyte, and specimen B contains the metal annealed. Some of the lines of both patterns show dense spots which on close examination appear to be very flat ellipses. Such spots have been shown by McKeehan[6] to be images of the source of X-rays produced by the presence, in the specimens, of large crystals with uniformly oriented lattices.

Film No. 2 shows that the diffraction pattern produced by specimen No. 1 contains without displacement all the lines found in the pattern produced by specimen B. The lines in the pattern produced by specimen No. 1, however, show no dense spots similar to those found in some of the lines in the pattern produced by specimen B which were described in the preceding paragraph. In addition to the lines found in the pattern produced by specimen B, the pattern produced by specimen No. 1 contains a number of comparatively faint but clear outlines which have

[3] Hull, A. W.: Physical Review, Vol. X, No. 6 (1917) 661.
[4] Westgren, Arne: Jour. Iron & Steel Institute (British), Vol. C, III, No. 1 (1921), 303
[5] Westgren and Phragmen: Jour. Iron & Steel Inst. (British), Vol. CV, No. 1 (1922), 241.
[6] L. W. McKeehan: Jour. of the Franklin Institute, Vol. 194 (1922). 87.

been identified, in the manner already described, as belonging to the pattern of crystals of the iron carbide, Fe_3C. These diffraction patterns then show that the annealed specimen (No. 1) which has a typical pearlite and cementite microstructure consists of a mixture of normal α iron and iron carbide (Fe_3C) crystals.

The patterns produced by specimens Nos. 2, 3, 4 and 5 are particularly interesting. First, because of the absence from them of all the lines pertaining to the carbide, Fe_3C pattern, and second, because of the presence in them of lines pertaining to both the α and γ iron patterns. The patterns are shown on photographic reproductions.

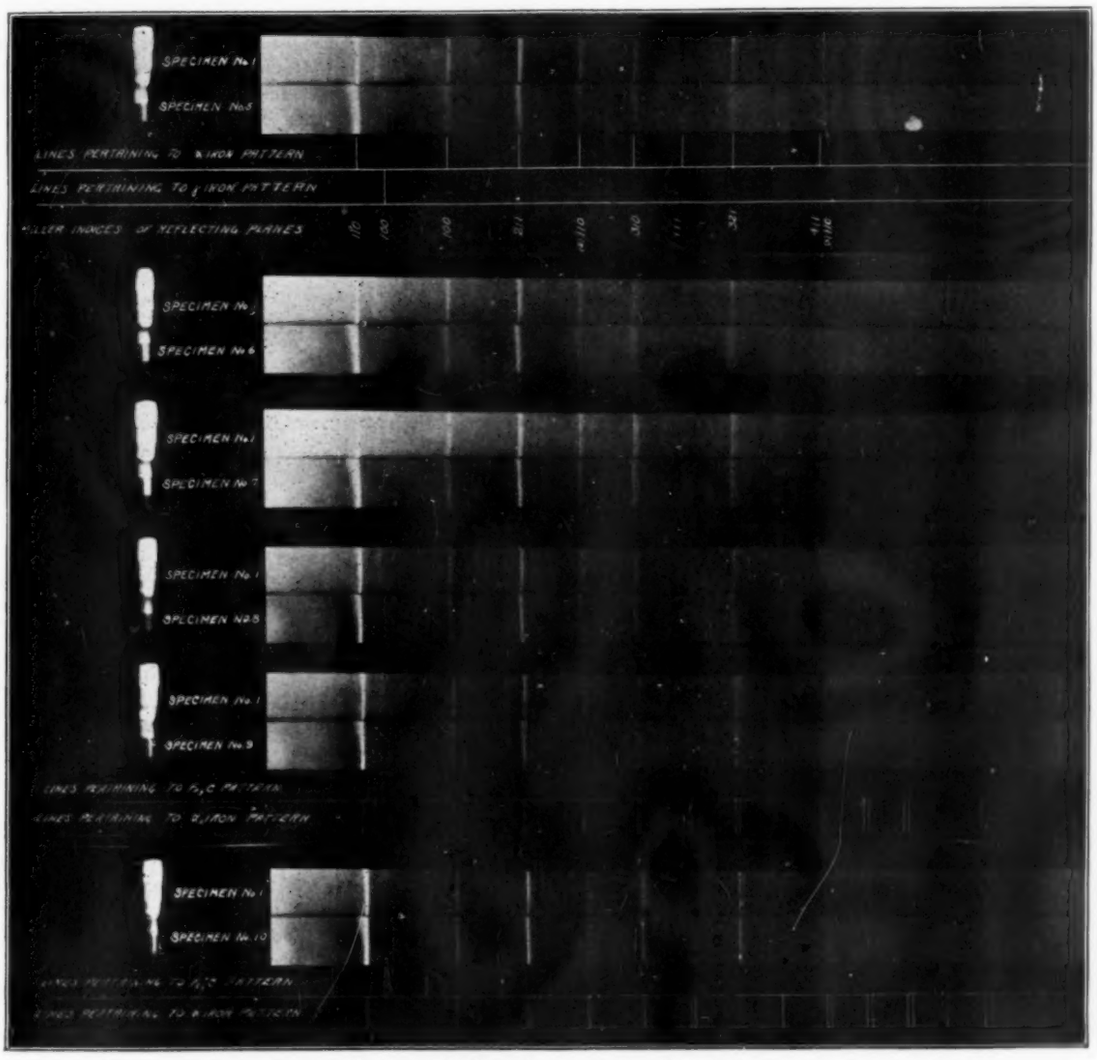


Fig. 4. Photographic reproductions of diffraction patterns (Films Nos. 6, 7, 8, 9, 10, and 11)

In the pattern produced by specimen No. 2 there is room for doubt as to whether the lines which have been indicated as having been produced by the 100^2 (second order spectrum) and 331 planes of the γ iron crystals might not have been produced by the 310 and 111 planes, of the α iron crystals, the corresponding interplanar distances in the case of the γ iron crystals being 0.903 Å and 0.828 Å and in the case of the α iron crystals 0.904 Å and 0.825 Å respectively. A close examination of the photograph, however, shows that the line identified as having been formed by the 100^2 plane of the γ iron crystals is somewhat further to the right than the line known to have been formed by the 310 planes of α iron in the pattern, on the same film, produced by sample No. 1. Furthermore, in the pattern produced by specimens Nos. 3, 4 and 5, in which specimens it is known that the austenite is successively more completely transformed, the line shifts successively further to the left and becomes weaker until in the pattern produced by specimen No. 4 it is almost exactly in coincidence with the line in the pattern produced by specimen No. 1 which line is known to have been produced by the 310 planes of the α iron crystals. In the pattern produced by specimen No. 5 this line has gained considerable in strength and has shifted still further to the left until it occupies a position with respect to the corresponding line in the pattern from specimen No. 1, which is occupied by all other lines of the α iron pattern in the diffraction pattern produced by specimen No. 5. For these reasons this line is identified as pertaining to the γ iron in the patterns produced from specimens Nos. 2 and 3, and to the α iron in the patterns produced by specimens Nos. 4 and 5. Similarly, the line in the pattern produced by specimen No. 2, which is identified as having been produced by the 331 planes of the γ iron crystals, will on close examination be found to be

displaced a little to the left of the line in the pattern from specimen No. 1, which line is known to have been produced by the 111 planes of α iron crystals. In the pattern from specimens Nos. 3 and 4 this line is not distinguishable at all and in the pattern from specimen No. 5 it appears in the proper position to identify it as having been produced by the 111 planes of the α iron crystals.

In the pattern from specimen No. 2 there is also a plainly distinguishable line just to the left of the line produced by the 211 planes of the α iron crystals. This line does not belong to the typical patterns of either the α or γ iron crystals and its presence is still unaccounted for.

In Table III is shown the number of lines pertaining to the typical patterns of α and γ iron crystals which are found in the diffraction patterns from specimens Nos. 2, 3, 4 and 5.

Table III

Specimen producing pattern	Number of lines visible in pattern pertaining to α iron	pertaining to γ iron	Total	Remarks
No. 2	5	7	13	
No. 3	5	4	9	One not identified.
No. 4	6	3	9	
No. 5	8	1	9	

All the lines in these diffraction patterns are more or less diffused and broadened, and are less dense than corresponding lines in the pattern produced by specimen No. 1, which appears alongside. The broadening of the lines pertaining to the γ iron pattern extends about the same distance from each side of their normal position, while the broadening of the lines pertaining to the α iron pattern in most cases extends to the left of their normal position.

The comparative density of a line, other things being equal, will of course depend on the amount of the material, producing the line, which is present in the specimen. Broadening and diffusing of lines has been shown by Scherrer[7] to be produced in proportion as the size of the diffracting crystals becomes smaller. The broadening of the lines from this course should extend practically equal in both directions from the normal position of the line in the pattern. Diffusion and broadening of lines might also be produced if the space lattices in some or all of the crystals were slightly distorted or varied slightly in dimensions, the distortion or variation in size being so small that the line produced by one size or shape of space lattice overlapped the line produced by the next size of shape. In this case the extent of the broadening of the line and the direction in which it extended from the normal position of the line should give some indication of the manner in which the space lattices differed from each other.

These considerations, however, have not as yet enabled the writer to definitely explain the behavior of all the lines in these diffraction patterns. It is thought that their behavior will probably be found to be closely associated with the mechanism of transformation of the γ iron crystals to α iron crystals. For the present, it can only be said that the phenomenon probably indicates the presence in the specimen of crystals of very small size, or having slightly distorted, enlarged or contracted space lattices, probably all.

The photo-micrographs of specimens Nos. 2 to 5, inclusive, show that in micro-structure they cover very well the martensitic range, No. 2 at one extreme, being martensitic with some indication of the austenitic and No. 5, at the other extreme, being martensitic with an indication of the troostitic.

It is evident, therefore, that the martensitic structure indicates the presence, in the specimen, of a mixture of α and γ iron crystals, the proportion of γ iron crystals decreasing and the proportion of α iron crystals increasing as the structure changes from the austenitic toward the troostitic. The space lattices of the iron crystals probably suffer little, if any, distortion or change in dimensions as long as any of these crystals exist. The γ iron crystals, however, are evidently very minute and probably somewhat distorted, gradually increasing in size and becoming more nearly normal in space lattice form or dimensions as the troostitic structure is approached. The failure of any of the lines of the iron carbide (Fe_3C) pattern to appear in these diffraction patterns cannot be taken as conclusive evidence that the compound does not exist in these structures. It might be present in such small crystals as to cause the lines of its patterns, which are rather weak anyway, to be so diffused as to be indistinguishable from the darkening of the photographic film which is caused by the general (white) X-radiation from the specimens.

The photo-micrographs of specimens Nos. 6, 7 and 8 show that they have a troostitic structure, with a trace of the martensitic in specimen No. 6 and a trace of the sorbitic in specimen No. 8. The diffraction patterns produced by these specimens contain only lines pertaining to the α iron crystals. These lines are still somewhat diffused and widened, the widening extending toward the left end of the pattern, and decreasing in amount as the structure of the specimen approaches the sorbitic. The presence, in specimen No. 6, of a trace of the martensitic micro-structure would lead to the suspicion that some of the iron in that specimen was still in the γ form. The absence of lines pertaining to the γ iron from the patterns produced by this specimen does not preclude the possibility of this actually being the case. It is quite conceivable that some γ iron crystals remain but are so small in size and so few in number that the lines produced by them are so weak as to be indistinguishable. The failure to find in their diffraction patterns any of the lines of the iron-carbide pattern again does not give definite proof that the compound is not present, either in small amounts or in the form of very minute crystals.

In specimen No. 9 the micro-structure is shown to be sorbitic. The diffraction pattern produced by it contains not only all the lines of the α iron pattern, but also some faint lines of the iron carbide pattern. The lines of the α iron pattern are seen, by comparison with the corresponding lines in the pattern from specimen No. 1, which is shown as the same photographic film, to be but very little over their normal width, indicating that the α iron crystals in the two specimens are of the same order of magnitude as the crystals in specimen No. 9. The presence of some of the lines of the iron carbide pattern shows conclusively that in this specimen there are present crystals of the compound in appreciable number and of appreciable size.

The microscope shows specimen No. 10 to still have a sorbitic structure, but also that the iron carbide crystals have at least begun to collect in irregular shaped globular masses in the matrix of more or less pure ferrite. The diffraction pattern produced by this specimen is practically a duplicate of the pattern produced by specimen No. 1 on the same photographic film, with the exception that the lines pertaining to the iron carbide pattern are not as strong in the former as in the latter. The only difference between the conditions of the material in specimens No. 1

[7] Gottinger Nachrichten, Sitzg., 26, Jul. 1, 1918; R.Zsigmondy, Kolloid Chemie, 3 Aufl., Leipzig, 1920, page 387.

and 10, which has been indicated, is in the distribution of the iron-carbide crystals in the matrix and possibly in their size.

Summary

The evidence discussed above shows that, at ordinary temperatures, in plain carbon steels of hyper-eutectoid composition, the crystal structure, as shown by the X-ray spectrometer, varies through a continuous series from that existing when the metal has been very rapidly cooled from a temperature in or above the critical range to that existing when the cooling has been very slow from a temperature above the critical range.

Typical micro-structures are developed in such steels depending upon the portion of this series to which the crystal structure existing in them belongs. These typical micro-structures have long been recognized and the range of the crystal structures which each indicates has been shown to be as follows:

1. The martensitic micro-structure indicates the existence of a mixture of α and γ iron crystals, the proportion of γ iron crystals decreasing and the proportion of α iron crystals increasing as the structure approaches the troostitic. The space lattices of the γ iron crystals apparently do not suffer much, if any, distortion as long as any of these crystals exist. The space lattices of the α iron crystals, however, are probably somewhat distorted, the distortion decreasing as the troostitic structure is approached.

2. The troostitic structure represents a condition in which iron crystals are present only in the α form. The space lattices of these crystals are also probably somewhat distorted, but to a lesser extent than in the martensitic structures. As the structure approaches the sorbitic this distortion of the space lattices decreases.

3. In the condition denoted by the sorbitic structures, there exists a mixture of α iron and very minute iron-carbide crystals. The probable distortion of the space lattices of the α iron crystals disappearing and the size of the iron carbide crystals growing as the micro-structure approaches the pearlitic.

4. In the alloys having the pearlite and cementite structures there is a mixture of perfectly formed α iron and iron carbide crystals.

The X-ray diffraction patterns of this series do not definitely indicate the disposition of the carbon atoms in the martensitic and troostitic micro-structures. They do not positively show the presence of iron carbide crystals nor do they produce evidence that very minute crystals of the compound do not exist.

Acknowledgment.—The experimental work described above was performed in the laboratories of the Watertown Arsenal. For permission to work in those laboratories the writer wishes to express his appreciation to Colonel T. C. Dickson, Ordnance Department, United States Army, Commanding Officer of that Arsenal. In the laborious and often difficult work of preparing the specimens the advice and encouragement of Dr. F. C. Langenberg, Director of Laboratories at the Watertown Arsenal, was of the greatest value. The production of satisfactory spectrograms was made easy by the advice, assistance and cooperation of Dr. H. H. Lester, Physicist in charge of X-ray Laboratory at the Watertown Arsenal.

High Explosive Shell Exudation

By

G. C. HALE

THE only explosives used during the World War by the United States Government in loading shell for the Field Artillery were TNT, 50/50 amatol and 80/20 amatol. The two last-mentioned explosives were mixtures of TNT. with 50 per cent and 80 per cent of ammonium nitrate, respectively. The British Government had used the amatols extensively prior to the entrance of the United States into the war, and the favorable opinion that had been formed as to the efficiency of these explosives aided materially in leading the United States Ordnance Department to adopt them as the standard fillers for high explosive shell.

The TNT. used in making the amatols was a commercial grade designated by Ordnance Department specifications as Grade III. It had a melting point between 76° C. and 79.5° C. and contained from 3 to 4 per cent of lower nitrated compounds as impurities, i. e., mononitrotoluenes and dinitrotoluenes. As these impurities are chemically stable and when present in small amount do not reduce appreciably the brisance or shattering power of the TNT., there was no apparent reason why their presence should be objectionable. The Grade III material could be obtained on the market much more cheaply, of course, than purified TNT., and was the logical material to use in view of these considerations.

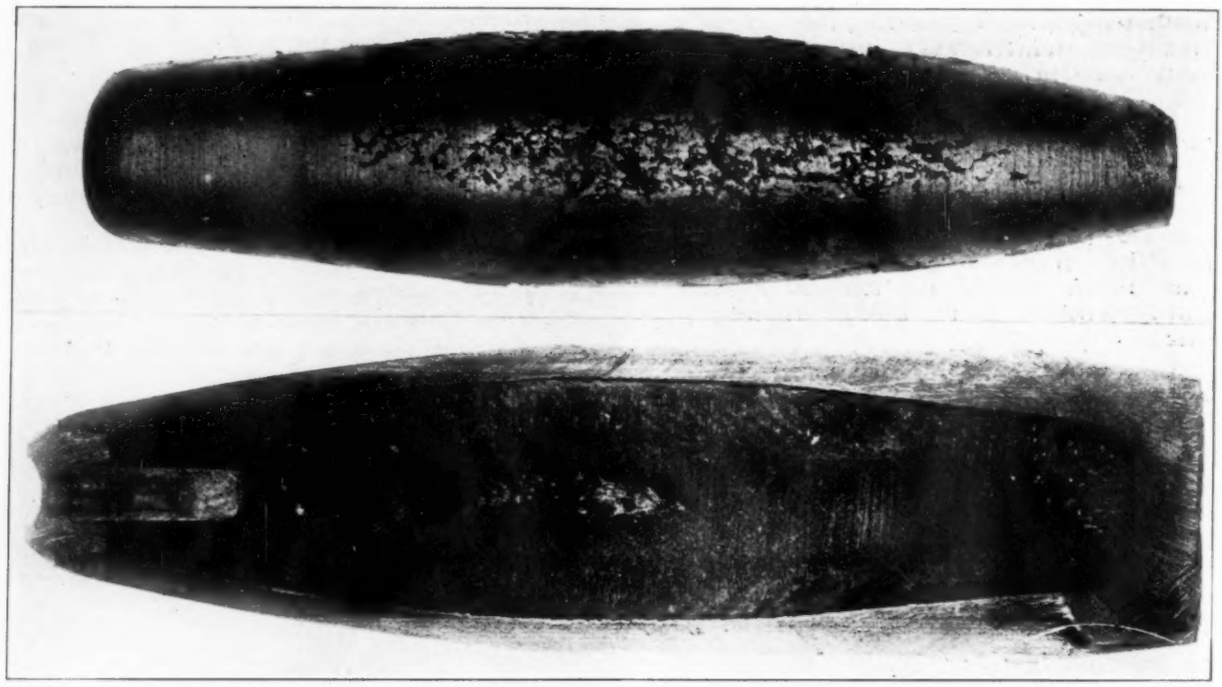
At the close of the war there remained unexpended a considerable quantity of shell of the various calibres. A certain portion of these was set aside to constitute a war reserve, the remainder was salvaged. The reserve was stored, under what was considered to be ideal conditions, at the various Reserve Depots established for the purpose by the Ordnance Department.

Within a year or so reports came from certain depots located in the south, that an oily liquid was exuding from the nose of some of the shells; this condition existed in spite of the fact that all shells were provided with boosters or metal screw plugs screwed tightly in position. Some of the exuding shells were later sent to Picatinny Arsenal for examination, but upon their arrival at the Arsenal it was found that the exudation had practically ceased, and no appreciable quantity of the oil could be collected for examination. An examination of the TNT. from either the TNT.-loaded or amatol-loaded shells did not reveal any unusual condition either as to the quality of the explosive

or the general nature of the loaded shells. In the meantime it was found upon removing the screw plugs from some of the exuding shells, that a gas was being evolved from the charges. In some cases the gas pressure was so great that the oil in the booster cavity was scattered about profusely when the screw plugs were removed.

During the past year the Research Laboratory at Picatinny Arsenal began an extensive investigation with a view to obtaining a definite solution of the problem. The Curtis Bay Ordnance Depot in Maryland and the Pig Point Ordnance Depot in Virginia were visited during January, 1923, in an attempt to collect a sufficient sample of the oil for examination, and to determine the extent to which the shells were exuding. Although there were many shells at each depot which showed numerous streaks left by oil that had exuded during previous summers, no shells were found to be exuding at the time. A visit was then made to the Charleston Ordnance Depot in South Carolina and there a large number of amatol-filled shells were found which had previously exuded profusely; from some of these a dark brown oil was slowly exuding at the time. By removing the screw plugs from a number of the shell and allowing the oil to flow from the booster cavity, a sufficient sample was obtained for examination. Although there was no considerable gas pressure in any of the shell inspected, a low gurgling noise coming from within a few of the shell, indicated that gas was being evolved from the charges. The sample of oil collected also gave evidence of an escaping gas and the stoppers to the sample bottles had to be wired firmly into position in order to resist the pressure. A chemical examination of the oil and the gas which came from it, together with a series of physical tests on TNT., amatol, and shells loaded with these materials finally led to a definite conclusion as to the causes of exudation and gas pressure in the shells, and indicated the significance that must be attached to the existence of such conditions in shell that are being held as a war reserve.

Exudation of oil from TNT. and amatol-filled shells is not the result of a chemical reaction within the shell, but is dependent upon the presence of the lower nitrated toluenes which exist as impurities in Grade III TNT. Although the setting point of the TNT. is 76° C. or above, there are minute particles of the material in which the proportion of impurities is greater than in the mass of the explosive, and such particles following a well-known principle of organic chemistry have a lower melting-point than other portions of the material in which the amount of impurities is less. During the hot seasons in southern climates the temperature is sufficiently high so that the heat upon penetrating the shell wall causes a melting of the particles of TNT. having the highest percentages of impurities. Small drops of oil are thus formed—at first along the interior wall of the shell. As the heat penetrates the charge, more and more of the oil is formed; the drops coalesce and finally small streams of the oil run irregularly through the mass of explosive. At the same time the explosive charge, which is fairly near its maximum density, expands with the rising temperature and the oil is actually squeezed from the charge into the open space of the booster cavity. When the booster cavity is filled the oil is forced out if the screw plugs or boosters do not fit sufficiently tight.



TNT Charge from 155-mm. Shell which showed Exudation
Above: Pitted surface of charge next to shell wall which resulted from flow of oil along the surface
Below: Region along shell wall of low density due to escape of oil

The oil which exudes from the shell is explosive in nature but is more difficult to detonate than TNT. Thus the presence of the oil in itself does not constitute a danger in using the shell for firing. It is of great importance, however, to remember that the escape of the oil from the shell leaves the charge in a very unsatisfactory condition. The density of the charge is, of course, decreased and numerous small cavities exist in the mass, especially along the shell wall. These cavities appear as small irregular channels, and result from the flowing of the tiny streams of oil through the charge. Such a condition within a charge is dangerous, in that it might allow premature explosion of the shell, upon set-back in firing from a gun.

The Scientist and the Engineer as Reserve Officers

By

F. E. WRIGHT

DURING the recent war many scientists and engineers entered the Army and were assigned as officers in the Ordnance Department, the Chemical Warfare Service, the Signal Corps, or the Engineers, to tasks and problems involving research work on subjects more or less connected with their peace-time activities. As a rule, these men had had little military training and functioned essentially as technical experts, with none of the duties of an Army officer in the ordinary sense, and yet the records show that the appointment of these men to officer rank was a wise step, because, in war time the prestige of the Army counts for much in getting certain things done. The officer, so assigned to special tasks and generally kept there because of his special qualifications, had commonly no illusions about his lack of training and suitability for service with troops, but he was so successful in solving the problems allotted to him that, on his retirement to civil life, he was persuaded to join the Officers Reserve Corps. A large number of staff experts of this type have now been carried on the list of Ordnance Reserve Officers for three or four years, but they have done little or nothing for the Army during that period and have been seemingly remiss in the fulfillment of their duty as reserve officers. There are, however, good reasons for this lack of interest and initiative; the trouble lies not entirely with the reserve officer, nor yet entirely with the Army.

WAR DEPARTMENT
OFFICE OF THE CHIEF OF ORDNANCE
WASHINGTON

July 12, 1923.

Editor,
ARMY ORDNANCE,
Washington, D. C.

Sir: I have read Colonel Wright's article on "Scientists and Engineers as Reserve Officers" with great interest. Colonel Wright has touched a vital spot in our war preparations. After all is said and done, the most important element in our national defense is *trained men*, and it is especially important that those possessing special scientific and technical qualifications be placed where their knowledge will be available to assist in guiding the peace time development of war material and, so that in the event of a national emergency, they may assume promptly their appropriate share in the national defense.

Colonel Wright's work in optical glass during the late war, and his post-war book, "The Manufacture of Optical Glass and Optical Systems," make his survey of the situation of particular interest.

The question of training the personnel necessary in war embraces, of course, not only the training of scientists and engineers, but of executives, manufacturers and individuals of many other classifications. The problem of the Ordnance Department is particularly difficult in that a very wide variety of categories is required and it is not possible to adopt a set course to cover the ground. The peace-time personnel of the regular Ordnance Department and available funds are small and the problems and difficulties are many and varied. It is impossible, therefore, to take all problems simultaneously and solve them promptly at the present time. The Department welcomes the assistance and cooperation of reserve officers and others in working toward a solution. It is hoped that Colonel Wright's article will bring out a general discussion of the subject.

C. C. WILLIAMS,
Major General, Chief of Ordnance, U. S. A.

What are the duties of a scientist or engineer reserve officer assigned to staff duty? Whose task is it to assign these duties and to see that they are carried out? Before attempting to answer these questions let us consider briefly why a man of this type with little or no military training is given a commission in the Army and performs, as an officer, a service totally different from that of the line officer, and yet equally essential.

In the case of the reserve *line* officer, assigned to one of the combatant units, the situation is thoroughly understood; the reserve officer realizes that he must train himself in certain definite subjects in order to be able to command troops successfully. The Army realizes this even more forcibly and to that end has divided the country into corps areas; it has assigned reserve officers in these areas to definite units and has made provision for instructing and training them annually for a short period. The kinds of instruction required by these officers have been thoroughly investigated, with the result that the Army can set for each reserve line officer the tasks best suited to his rank and branch of the Service. The responsibility for the kind of training given to its reserve line officers rests directly with the Army.

In the case of the scientist or engineer *staff* officer whose best service to the Army and to the Country is along highly technical lines and not necessarily with troops, the duties are of a different character and the Army is in a position to give him only a small part of the training required. In many cases the reserve officer brings to the Army special information and skill not found within the Army itself, but nevertheless, necessary to the proper development of war-time material.

The duties and qualifications of a scientist or engineer reserve officer are quite different from those of the line officer. The one is essentially a specialist whose task it is to solve problems of a technical nature; the other is essentially an executive, trained to meet all manner of situations in a general way and purposely shifted from post to post to acquire adaptability and broad experience in the handling of men. The one should not be judged by the standards of the other. In the case of examination for promotion, the scientist or engineer officer is liable to make a poor impression before a Board of Line

officers; he knows nothing of military law, of camp sanitation, etc., and has only a general knowledge of the Army organization; but even at that he will probably make a better showing than would the line officer were he examined by a Board of technical experts. In time of war the Army without its technical experts, as represented by the scientist and engineer reserve officers, would be like the philosopher in the sinking boat who knew a great deal about many subjects, but who did not know how to swim. In the last analysis the scientist and engineer staff officers are just as essential to success in war as are the line officers; but they are a new species, a *rara avis*, which does not fit into the old classification. For a man of this type to attend a Reserve Officers' training camp serves little purpose except to give him a general idea of the functions of the several branches of the Army. The money thus spent on him brings little return to the Army and might better be spent on the training of a line officer. The information the scientist there gathers is of little value to him in his special capacity as a technical expert. To the regular army officer trained as an executive and accustomed to be shifted from one task to another, this argument may not appeal; but to the civilian who has specialized along certain lines, the picture is different because he realizes the need, in technical research problems, for concentration along a few restricted lines if he is to master them thoroughly, and his value to the Army lies chiefly in his expert knowledge of his subject. The same comments apply to the manufacturing industry and are there recognized by the larger corporations to the extent that research and technical laboratories are maintained as integral parts of their organizations.

The question arises "Is it desirable to give commissions to men of this type whose duties are so far removed from those of the line officer? Will not every purpose be served by adding them, for the period of the war, to the Army staffs of civilian technical experts?" This arrangement would tend to preserve intact the corps of officers in the sense of officers qualified to command troops in action. A century ago no other kind of officer was even considered, but in recent years, and particularly during the past decade, our opinions have changed materially regarding many subjects, including war, what war means, and the rôle necessarily played by the industrial forces of a nation at war, as well as by the field forces. We realize that, if for one reason or another war has been declared, the nation as a whole is involved and the Army and Navy assume control and maintain control until after the cessation of hostilities. Modern warfare has become so complex and technical in character that the supply of warfare matériel available to a nation determines in a measure the limit of its possible military effort. For this supply the Army and Navy look to the industrial resources of the country; and, in effect, take charge of, and direct the work of the factories of the country, so that these, in turn, function as an integral part of the Army and Navy. From this viewpoint the giving of commissions to civilian experts to develop and to direct the agencies for the production of war matériel is wise because the Army or Navy connection gives them a psychological lever which, for the accomplishment of results in certain situations, is a factor second to none in efficacy.

A number of scientists and engineers are now enrolled as Ordnance reserve officers, but their present contact with the Army practically ends there. Their names are on the list, but the Ordnance Department has thus far made little effort to maintain their interest. It is true that through ARMY ORDNANCE and the annual meetings of the Army Ordnance Association much is being done to keep the members posted regarding new developments in Ordnance matériel. But this covers only part of the field. The appointment of a scientist or an engineer in the Officers Reserve Corps and his assignment to a staff position in the Ordnance Department means that the Army, in preparing for a future contingency, recognizes the importance of, and need for, his special services and expects him to keep himself prepared to do his part effectively when he is called to active service. At the time of his appointment, or shortly after, the officer should be assigned to a definite field of activity in order that he may realize exactly what will be expected of him when ordered to active duty. In some cases the Ordnance Department has not done this, and to that extent it has not thus far utilized its specialist reserve officer personnel adequately.

The reserve officer, having been assigned to a definite field which, in most cases, is somewhat out of the sphere of activity of the Army, becomes in a measure responsible for this field. The Army cannot be expected to prescribe the exact duties of the scientist reserve officer. In brief, the *responsibility for the development of his field or subsection on the Ordnance Department program rests with the reserve officer himself.*

To take a specific case: During the war the writer was assigned, as an officer, to a series of different problems connected with the production of optical glass and of optical instruments. On retirement to civil life he was commissioned in the O. R. C. and assigned to the Fire-control Instrument Section of the Artillery Division of the Ordnance Department. This assignment obviously means that in case of war he will be put on problems connected with his previous war-time activities. The question arises "What are his present duties as a reserve officer?" The Ordnance Department has not undertaken to define these duties and apparently does not intend to do so. How then can he keep himself informed regarding current developments in optical matters and ready to contribute effectively to the army program in case of war? Obviously he must keep track of the literature in certain branches of optics, maintain friendly relations with the scientists and optical engineers of the country, interest himself in the work of the American Optical Society and of scientific apparatus makers; keep in touch with the optical work at Frankford Arsenal; and seek to build up in the O. R. C. a potentially efficient subsection on the production of optical glass and optical instruments by persuading properly qualified younger men to enter the Officers Reserve Corps as optical engineers. In the event of war these officers will be ready to take over different elements of the situation, and during peacetime to carry forward the work.

In time of war the question of personnel is always the most vital factor and the same degree of attention should be paid to it by the Ordnance Department that is given to the industrial program. But *responsibility in the matter of personnel can and should be shared with the O. R. C.*

How best to effect this and to make scientist and engineer reserve officers feel their responsibility individually and to realize that the initiative in these matters must come chiefly from them and not from the Army, is another matter; possibly it can be done through the pages of ARMY ORDNANCE, THE MILITARY ENGINEER, and the journals of other branches of the service, to which reserve officers should be encouraged to contribute more frequently than heretofore. The development of Ordnance matériel is highly important, but the development of re-

sponsible and resourceful Ordnance Reserve Officers is still more important.

The best method of stimulating the interest of the reserve officer is to give him something worth while to do and to make him responsible for its accomplishment. If the Army were to require from each scientist and engineer reserve officer an annual progress report on his special field of endeavor, or on some topic in that field, with emphasis on its significance to the Army, this might serve a good purpose. It would give the officer a definite and interesting task to perform. Each report would give the Army authoritative information on definite topics from a specialist in the field; it would also serve as a criterion by which to gauge the interest and standing of the staff reserve officer with reference to promotion and would aid in maintaining contact between the Army and its reserve staff officers. The Army should not pay for these reports, but it should give to the reserve officer a statement of the Army matériel requirements within his own field; in certain cases it should invite the reserve officer to visit one of the arsenals for study and for consultation on definite research or technical problems. Training of this kind is particularly valuable because it serves to awaken the interest of the officer and to fix his attention on actual problems. Most officers are glad to give their services in projects of this sort, especially if reimbursed for traveling expenses.

The primary purpose of this or any other plan is to enable the Ordnance Department to survey its reserve officer personel periodically and to ascertain to what extent the field of its war functions is competently covered. In peace time it is a difficult, but still a relatively straightforward matter to prepare a manufacturing program suitable for the needs of an Army of given size; and, because of this fact, there is a tendency to overemphasize the matériel side of the game and either to overlook the part to be played by personnel or to feel that, when an emergency arises, competent personnel can be quickly located and brought together and a working organization built up over night, as it were. This attitude may be correct in certain cases, but the last war proved that, in general, it is not justified and may lead to endless difficulties and waste of time and energy.

The experience of the recent war demonstrated the wisdom of the Army in giving commissions to scientists and engineers qualified to tackle certain research and technical problems, but it also proved the folly of assigning to such tasks officers not properly trained along special lines. Although conscientious to a degree, these officers at times actually did more harm than good, and impeded progress in the proportion that they were energetic and eager to assist. The records show that many of the successful scientist and engineer officers have joined the O. R. C., largely as a patriotic duty, and the questions "How can these officers be kept best prepared for war duty?" "What part can the Army play in this matter?" "How much responsibility rests with the individual officer?" may be answered tentatively as follows:

Responsibility rests with the Army to assign its scientist and engineer reserve officers to special tasks; to outline for each officer his particular field or group of problems; to keep him in touch with the research problems of his field that are being attacked within the Army; and to stimulate and maintain his interest in the game by requiring of him an annual progress report on some phase of the work in his field. Once the field of his wartime activity has been designated, the *responsibility rests with the reserve officer himself* to survey the field, to keep himself posted on the literature covering this field, to keep track of, and to bring into the O. R. C. the available personnel throughout the country especially suitable to form a nucleus which will be ready to serve in case of war and which in peace-time will continue to carry on and to maintain the section through the passing years.

The Ordnance Engineer 150 Years Ago

HENRY B. MACHEN
202 RIVERSIDE DRIVE
NEW YORK CITY, N. Y.

September 22, 1923.

THE EDITOR,
ARMY ORDNANCE,
Sir:

Recently when passing through the churchyard of Old St. Paul's Church on lower Broadway, I noticed the following inscription on a tombstone located in the front row facing the main entrance to the church:

HERE LIES THE BODY OF
Charles Hadley
LATE ARMOURER TO YE OFFICE
OF ORDNANCE WHO DEPARTED
THIS LIFE THE 26 OF JUNE 1775
AGED 48 YEARS

The church was in those days next to Old Trinity in prominence and the location of the late armorer's grave indicates that he too stood well in the community. It is of interest as showing the position of the Ordnance Office 148 years ago.

Very sincerely yours,

HENRY B. MACHEN,
Major Ord. O. R. C.

The Relation Between the Dynamic and the Static Tensile Tests

By

HAROLD ALBERT NISLEY*

A KNOWLEDGE of the mechanical properties of the materials to be employed has always been necessary to the rational designing of any kind of structure or machine. Thus the question of testing the materials of construction has been under consideration from the early ages.

The simplest method of testing materials is by direct loading, and the earlier researches were carried out by this method. Galileo (1638) made many tests on a small scale by this means. But this method is suitable only for weak materials and small sizes, because of the difficulty of handling heavy loads. From the time of Galileo eminent physicists and mathematicians have made endless experiments, largely from a purely scientific and theoretical viewpoint, to determine the physical properties of materials. From these investigations, carried on during the latter quarter of the 17th century and during the 18th century, were deducted the various laws of elasticity which constitute the basis of later scientific research.

When, at the beginning of the 19th century, the demand came for tests on a large scale, it was necessary to devise other means of applying the force than by direct loading. Within a few years there were devised testing machines employing the three arrangements now found in modern testing machines.

These arrangements are:

(1) Load applied by hydraulic press—no weighing device but load calculated by pressure on ram.

(2) Load applied by gearing at one end and measured by weighing lever at other end.

(3) Load applied by hydraulic press at one end and measured by weighing lever at other end.

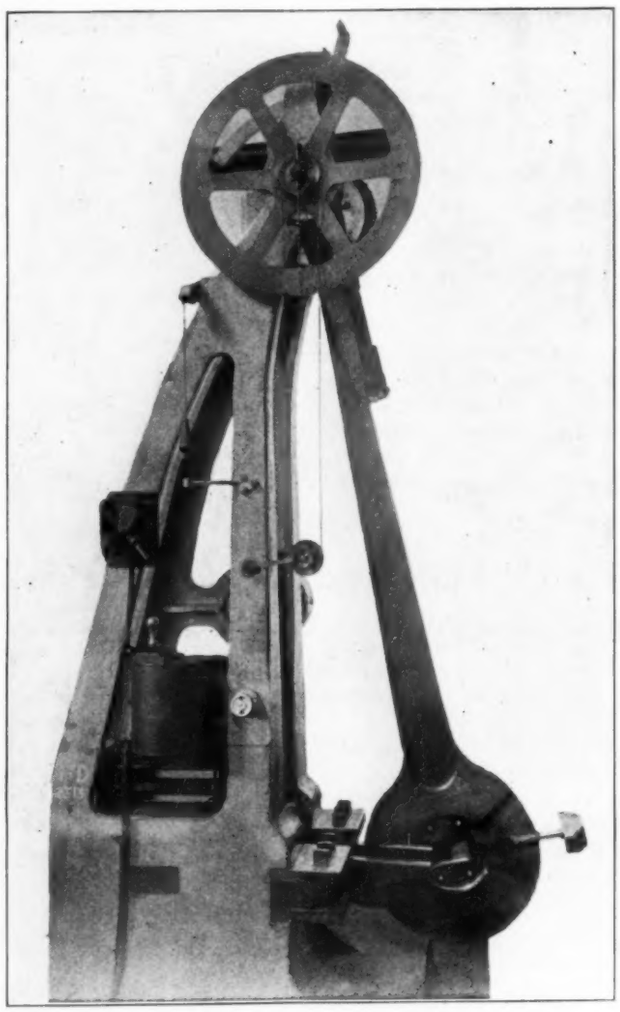


Fig. 1. Charpy Testing Machine (300 kgm.)

As early as 1813 method (1) was used by an English concern, Brunton and Co., in building a cable testing machine.

Method (2) was used by Major Wade, of the U. S. Army, in building one of the first machines for making physical tests. This first machine was built in 1856, and was later remodeled and improved by Captain Rodman.

Method (3) is always associated with the name of David Kirkaldy, who in 1866 built his famous testing machine of this type in London. In 1879, Mr. A. H. Emery constructed a machine of this type of 800,000 lbs. capacity, which is still in daily use at the Watertown Arsenal.

All these machines mentioned above are for so-called static testing, that is, where the applied load is gradually increased. This is not, strictly speaking, a static test, and results will vary with the rate of application of the load. However, Bauschinger has shown that the time element is of no consequence within the ranges of practicability, for the velocity of moving parts is inappreciable for all practical purposes. The term "static" test will be used throughout the discussion to denote this method of testing.

The Impact or Dynamic Testing Machine

With the increase in speed of machine parts, the desire to test a material under approximately actual service conditions led to the introduction of impact or dynamic testing. The application of shock tests to materials has also

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been practiced to a limited extent from the early ages. It was only natural, where a material was ultimately to be subjected to rough usage in a structure or machine, to first test out the material by subjecting it to rough usage. But until comparatively recent years no attempt was made to measure the energy required to rupture the specimen. Impact testing has in general followed industrial development. Up to about 1850, impact was studied by investigators more as a phenomenon and without regard to its probable application as a practical means of testing materials. During the next forty years impact testing development followed in a way the development of railroads and railroad materials. In 1849 an English Commission, appointed to inquire into the use of iron in railroad structures, published a report which was one of the earliest published accounts of the consideration of the practical application of previous theoretical knowledge of impact.

In 1857 Captain Rodman devised a drop weight machine for experiments on guns. A little later the drop test machine began to be widely used in testing railroad materials. In 1881 the U. S. Board for Testing Iron and Steel published results of tests on wrought iron and steel, using a drop test machine.

About this time, 1890, impact testing began to have a wider application. Many investigators took up the problem of measuring the energy absorbed by the specimen under test, and devised various pieces of apparatus for this purpose to be used in connection with the drop impact machine.

In 1897 S. B. Russel designed a pendulum machine similar to the later Charpy machine, but the practical application of the pendulum principle was made by Charpy in 1901. About the same time Fremont produced his falling weight machine, in which the work of rupture was measured by a calibrated sprint which was struck by the falling weight after striking the specimen. The Izod pendulum machine appeared in 1903, and in 1904 the Guillery rotary machine was introduced.

The four machines last mentioned are representative of the three classes of impact or dynamic testing machines in actual use in testing laboratories today. The Fremont machine is an example of the vertical ram type. The Charpy and Izod represent the pendular ram type. The Charpy machine is described in more or less detail below. The principle of the Izod machine is the same as that of the Charpy, but it differs chiefly in that the specimen is gripped at one end only as a cantilever beam. The third or rotating ram type is represented by the Guillery machine. Here the striking edge is attached to the periphery of a flywheel rotating about a horizontal axis with sufficient velocity to rupture the specimen. The specimen, on horizontal supports, is introduced suddenly in the path of the striking edge. The loss in kinetic energy of the flywheel is measured by the displacement of a column of water connected to a small vertical water turbine, the turbine serving as a tachometer.

Object of this Investigation

With the recent development of impact testing and the almost universal adoption of the impact test for routine work to supplement the static test, the question has arisen as to just what is the relationship between the *static* and the impact or *dynamic* test.

The results usually recorded in the static test are: the elastic limit, the ultimate strength, the total elongation over a specified gauge length, and the reduction of area. Whereas in the dynamic test, for all the various kinds of testing machines in present use, the results are obtained in units of energy. It is obvious that any comparison of the two methods must be made between units of the same kind. No relationship could be expressed between a linear quantity, such as force of linear distance, and a two-dimensional quantity, as energy, which is the product of force and distance. It would seem, then, that if sufficient data were taken in the static test to determine the total energy or work required for deformation and rupture of the specimen, any relationship between the two methods of testing would be shown on a comparison of the total energy required in each case.

Much attention has been given by able investigators to the comparison of the amounts of energy absorbed by specimens of a given material when ruptured under static and dynamic conditions. A number of attempts have been made to develop a definite percentage relationship between the results obtained by the two methods. The conclusions arrived at in the various cases have been more or less conflicting.

It was believed that this relationship was dependent upon the nature of the material undergoing comparison; that by changing the structure of the material, the value of the percentage relationship would also be changed, at least to a certain extent.

In this investigation a particular steel was selected, and its structure made to vary over a wide range by widely differing heat treatments. In the case of the static tests, the corresponding loads, elongations, and reductions of area were recorded for each specimen through the ultimate up to the point of rupture. The total work done was then determined in each case by integrating the plotted results. Thus it was possible to make a direct comparison of the total energy required for rupture of specimens when tested statically and when tested dynamically.

The object of the investigation was to determine just what relationship existed between the results of the static and dynamic tests for each heat treatment, and to show whether this relationship did, or did not, vary as a function of the structure of the material.

Description of Machines Used

Before taking up in detail a discussion of the procedure followed during the investigation, it would seem advisable to include at this point a brief description of the testing machines used. The dynamic tests were carried out on a Charpy machine of 300 kgm. capacity, while for the static tests a Riehlé machine was used.

The Charpy Machine (300 kgm.)—The Charpy machine was selected for the dynamic tests, for the following reasons:

(1) It is the machine in most general use for routine impact testing.

(2) It is one of the few impact machines designed for tension tests, and in this investigation it was desired to conduct the dynamic tests upon tensile test pieces of exactly the same size and shape as those used for the static tests.

The large machine was used in preference to the smaller one of 30 kgm. capacity because the size of test pieces used for tensile testing is more nearly the size of the standard static tensile test piece.

As the machine itself is quite well known, it will be described only briefly here, particular attention being paid to certain constants of the machine, such as weights and dimensions. A photograph of the machine used is shown in Fig. 1, which demonstrates clearly the method of attaching a tensile specimen. The pendulum hammer is tapped and threaded at the back for holding one end of

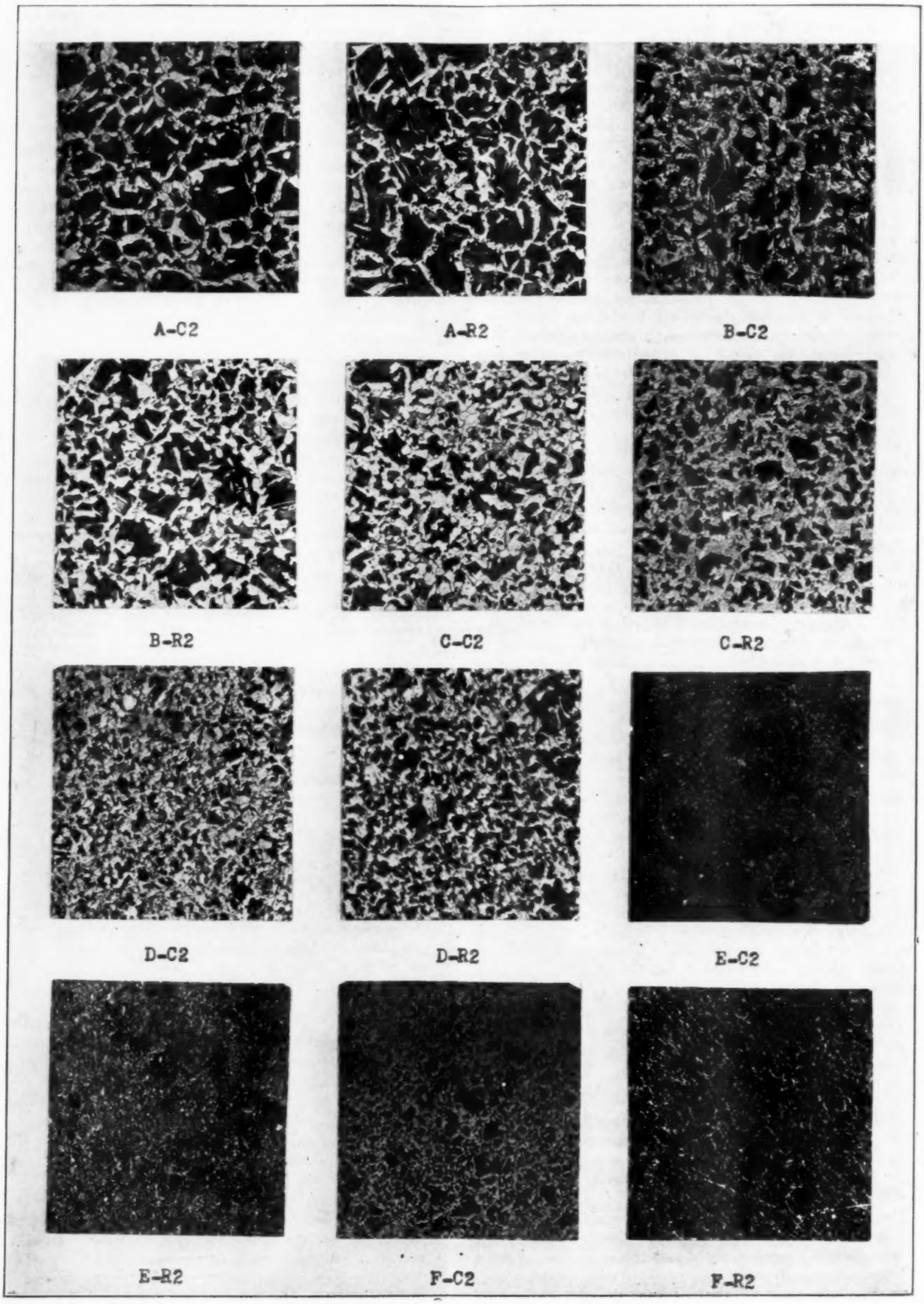


Fig. 2. Structural Photo-micrographs of Specimens After Heat Treatment

the test piece. On the other threaded end of the test piece is screwed a hardened steel block. When the pendulum drops, this block strikes against prolongations of the anvil and is stopped. The pendulum is suspended to swing about a horizontal axis on roller bearings, and an index hand is mounted on this axis with an easy friction fit and travels over a graduated circular dial with the hammer when this rises after fracturing the test piece.

The hammer is raised by means of a small motor and held up at its maximum starting angle by a catch which may be released by pulling the cord shown in the photograph. The angle of rise of the hammer after fracture of test piece is read off from the graduated circle.

The kinetic energy "K" available at the time of impact is equal to the product of the weight of the striking mass "P" by the height of fall of the center of gravity.

$P \times d\ (1 - \cos a)$ less the kinetic energy absorbed by mechanical friction and the air resistance of the fall, d being radius to center of gravity, a being the starting angle.

The kinetic energy "K" left after shock is equal to the product of the weight of the striking mass by the height of ascent of the center of gravity.

$P \times d\ (1 - \cos b)$ plus the energy absorbed by friction and air resistance during the ascent, B being the angle of rise.

The total energy absorbed is then equal to

K—K.

In order to determine the energy absorbed by friction and air resistance the pendulum is allowed to swing freely and the decrease in amplitude of swing noted; this gives a table of corrections to be applied for each angle of ascent.

Where *tensile* specimens are used for the impact test, in making calculations the weight "P" of the pendulum is increased by the weight of the broken end of the specimen carried away. And the starting angle is that angle which the line through the axis and the resultant center of gravity of the pendulum, with the test piece and tup attached, makes with the vertical. For, since the effect of the tup and test piece is to increase the height through which the center of gravity falls, the pendulum has a greater striking velocity than it otherwise would have.

The Riehlé Machine.—For the static tests the Riehlé testing machine of 100,000 lbs. capacity was used, chiefly because this type of machine is most generally used for static tests, especially in routine work.

The machine is representative of type (2) mentioned under the discussion of static machines above. It is too well known to merit a detailed description here. The power is applied to the lower end of the test piece by means of three vertical screws, which pass through the weighing table. These vertical screws are connected to the motor by a system of screw and spur gearing. The upper end of the test piece is attached to a frame which is fixed to the weighing table. The force applied to the test piece by the three strain screws is transmitted through this frame to the weighing table, and thence by a compound system of levers to the graduated weighing beam.

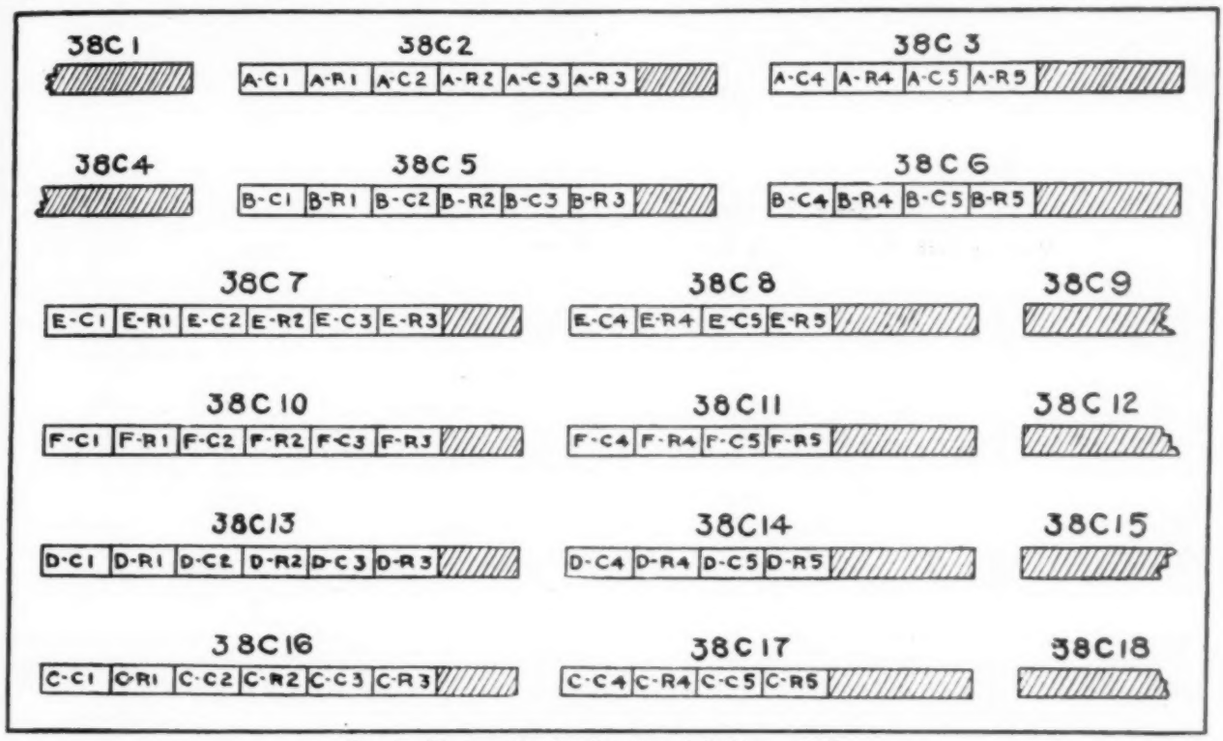


Fig. 3. Diagram Showing Location of Specimens in Bars

Description of Material and Methods of Testing

Steel Selected.—The particular steel selected for this investigation was a plain carbon steel, which upon analysis was found to have the following composition:

Constituent	*Percent*
Carbon	0.39
Manganese	0.70
Phosphorus	0.048
Sulphur	0.043
Silicon	0.265
Nickel	0.34
Chromium	0.11

This steel was available in square bars 1⅜ inch by 1⅜ inch and of lengths varying from 39 inches to 52 inches. Original length of rods had been approximately 10 feet, but all had previously been given a normalizing treatment, and each of the 10-foot bars had been cut in three pieces because of the limited size of the annealing furnace. Fig. 3 is a schematic diagram showing location of specimens in the bars from which they were taken. The markings, 38C1, 38C2, 38C3, etc., indicate the markings originally placed on the bars in the testing laboratory at the Watertown Arsenal, and have been preserved in this sketch for identification from the records of that laboratory. Each horizontal group of three bars in the sketch indicates the three bars that were cut from one 10 foot bar, and also shows their relative position in the longer bar.

exercised to insure absolute uniformity of heating. Attention is invited to the photo-micrographs (Fig. 2), which show the resulting structures obtained by the six different heat treatments.

Specimen Adopted.—It was desired that the specimens used for the dynamic and static tests should be as nearly identical as to form and dimensions as possible. Fig. 4 is a drawing showing all dimensions of the specimen selected.

The Dynamic Test.—A two-inch gauge length was marked on each specimen before being placed in the machine. The angle of ascent, elongation, and reduction of area were recorded in every case. The last few threads on each end of the test pieces were flattened to limit the whip of the specimen upon the tup's striking the anvil. For unless the threads fit exceptionally tight it was

Characteristics of the Charpy Machine

Machine Used—No. 180, Type No. 2, *Monton Pendule Systeme Charpy.*

	Metric Units.	*English Units.*
Weight of Pendulum	96.370 kg.	212.4592 lbs.
Radius to center of gravity	1.627 m.	5.3379 ft.
Radius to center of percussion	1.9045 m.	6.2483 ft.
Maximum starting angle	160°	
Free return angle corresponding to maximum starting angle	158°	
Velocity of impact (maximum starting angle)	8.733 m. sec.	28.6512 ft. secs.
Capacity	304.6 kgm.	2203.2 ft. lbs.
Distance from center of specimen to axis of rotation	2.000 m.	6.5616 ft.
Period of oscillation	2.7691 sec.	
Weight of block or tup	2.300 kg.	5.0706 lbs.

Heat treatments.—To obtain a wide range of variation of internal structure, six different heat treatments were applied. Throughout the remainder of this discussion they will be indicated as heat treatments A, B, C, D, E and F. For each heat treatment five dynamic and five static test specimens were taken. In marking the specimens, the first letter of each group indicates the heat treatment. The middle letter of each group "C" or "R" identifies the specimen as to static or dynamic test; "C" indicating a dynamic, or Charpy, test piece, and "R" indicating a static, or Riehlé, test piece. The numeral following the "C" or "R" of each group indicates the number of the specimen in that group. Having thus indicated the method of marking, a glance at the diagram will show how alternate dynamic and static test pieces were taken, and how correspondingly numbered specimens under any heat treatment occupied adjacent positions in the original bar.

The heat treatment given were as follows:

"A"—Held at 1100° C. for six hours and furnace cooled.

"B"—Held at 1000° C. for six hours and furnace cooled.

"C"—Held at 900° C. for six hours and furnace cooled.

"D"—Held at 850° C. for six hours and furnace cooled.

"E"—Held at 850° C. for one hour and quenched in water at 21° C.—drawn at 600° C. for one hour and air-cooled after the draw.

"F"—Held at 850° C. for two hours and air-chilled—drawn at 600° C. for one hour and furnace cooled.

In heat treating, all of the ten specimens of each group were placed in the same furnace, and great care was

noticed that the specimen with the heavy tup attached tended to sag slightly, thus preventing the tup from striking the anvil squarely. The weight of that portion of the specimen remaining in the pendulum, as well as that portion attached to the tup, were also recorded.

The Static Test.—On the Riehlé machine the elongations were measured up to the yield point by means of a Berry Strain gage. Here also, a two-inch gage length was marked on each specimen by a prick punch gage, before insertion of the specimen in the machine. After the yield point was reached in each case the strain gage was removed, the elongation being measured thereafter by a vernier. As but one man operated the machine the rate of loading was unusually slow. The load was applied in increments of 1,000 pounds. After each increment of load the beam was left balanced while a reading was taken of the elongation, and after removal of the strain gage, of the diameter also.

Comparison of Results

Table I gives a tabulation side by side for the dynamic and static tests for each correspondingly numbered specimen, comparative values of total work done, percentage elongation, and percentage contraction of area.

It is interesting to note how much more nearly uniform are the static results as compared to the dynamic results. In this connection it is seen by referring to the detailed data that for each heat treatment all five of the static specimens gave very approximately the same yield point, the same ultimate load, and the same breaking load. While in the dynamic tests the lack of uniformity ot results is much greater; they are as nearly uniform as would be expected from a dynamic test.

We note that in every case the total work done, the elongation, and the contraction of area is greater for the dynamic than for the static test. The difference between the corresponding functions for the two methods of testing is greatest for *work done* and is least for *contraction of area.* The ratio of work done statically to work done dynamically varies from 61.3 per cent for heat treatment "A" to 76.2 per cent for heat treatment "E," giving a difference of 15.1 per cent over the range of heat treatments used. The ratio of contraction of area

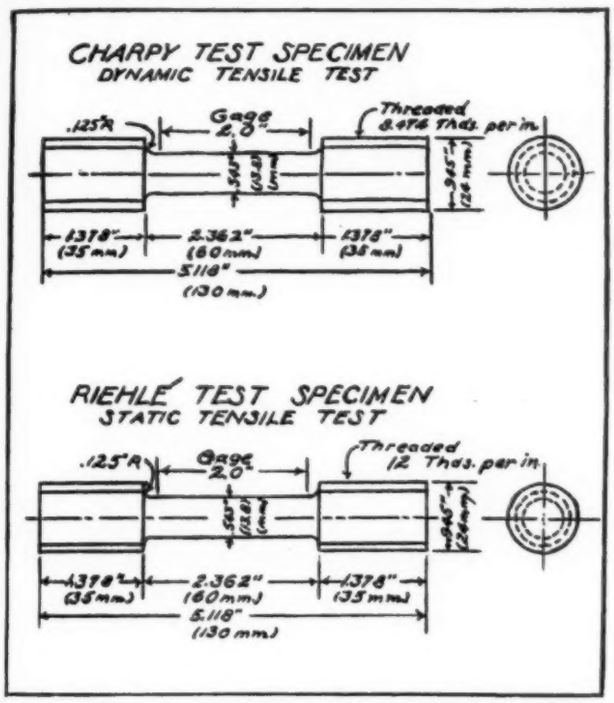


Fig. 4. Watertown Arsenal Testing Laboratory Standard Specimens

in static tests to contraction of area in dynamic tests varies from 87.3 per cent for heat treatment "A" to 99.5 per cent for heat treatment "E," a difference of 12.2 per cent over the range included. And the ratio of elongation varies from 81.9 per cent for heat treatment "A" to 92.7 per cent for heat treatment "E," giving a variation of 10.6 per cent over the range included.

It is interesting to note that the ratio of contraction of area for the two methods of testing varies very much in the same manner as the ratio of work done for the different conditions of structure.

Conclusion

In the light of the above observations, within the limits of this investigation, there appears to be no fixed percentage relationship between the results obtained upon a particular steel by so-called static and dynamic tensile tests. This relationship is apparently a function of the structure imparted to the steel by different treatments. However, the variation of the relationship is not large and seems to be confined to a certain limited range. It must be noted that this investigation has been limited to one particular steel of 0.39 per cent carbon content, and to unnotched tensile test specimens for both the static and dynamic tests.

From the various data obtainable from a static tensile test on this particular steel, the reduction of area seems to be the best criterion of the shock-resisting qualities of the material.

Comparative Results—Charpy vs. Riehle

Heat Treatment "A"

(6 hrs. at 1100° C. and furnace cooled)

Specimen No.	Work Done (Ft. Lbs.) Charpy	Work Done (Ft. Lbs.) Riehle	Elongation (Per cent) Charpy	Elongation (Per cent) Riehle	Contraction of Area (per cent) Charpy	Contraction of Area (per cent) Riehle
1	1154.7	678.67	27.75	22.0	39.3	31.3
2	1075.1	674.43	26.6	22.1	39.0	33.8
3	1086.6	648.30	26.5	22.5	39.0	35.2
4	1098.7	692.43	27.0	22.75	39.0	35.1
5	1122.9	700.65	28.5	23.2	40.4	36.1
Average	1107.6	678.90	27.5	22.5	39.3	34.3

Heat Treatment "B"

(6 hrs. at 1000° C. and furnace cooled)

Specimen No.	Work Done (Ft. Lbs.) Charpy	Work Done (Ft. Lbs.) Riehle	Elongation (Per cent) Charpy	Elongation (Per cent) Riehle	Contraction of Area (per cent) Charpy	Contraction of Area (per cent) Riehle
1	1154.7	678.67	27.75	22.0	39.3	31.3
2	1122.8	756.43	29.5	26.5	43.7	41.2
3	1074.5	760.00	28.5	25.75	43.3	31.5
4	1133.7	791.75	30.0	26.75	44.9	42.9
5	1080.6	748.86	29.3	26.5	44.4	43.7
Average	1109.3	756.89	29.5	26.2	44.0	42.1

Heat Treatment "C"

(6 hrs. at 900° C. and furnace cooled)

Specimen No.	Work Done (Ft. Lbs.) Charpy	Work Done (Ft. Lbs.) Riehle	Elongation (Per cent) Charpy	Elongation (Per cent) Riehle	Contraction of Area (per cent) Charpy	Contraction of Area (per cent) Riehle
1	1200.3	776.66	33.3	27.3	47.6	45.6
2	1110.9	786.43	31.0	27.5	46.6	45.5
3	1090.7	792.88	29.8	28.0	46.8	46.4
4	1100.2	782.65	31.0	27.5	46.6	45.0
5	1136.1	787.31	31.5	27.5	47.4	45.5
Average	1127.6	785.19	31.3	27.6	47.0	45.6

Heat Treatment "D"

(6 hrs. at 850° C. and furnace cooled)

Specimen No.	Work Done (Ft. Lbs.) Charpy	Work Done (Ft. Lbs.) Riehle	Elongation (Per cent) Charpy	Elongation (Per cent) Riehle	Contraction of Area (per cent) Charpy	Contraction of Area (per cent) Riehle
1	1273.5	831.10	34.5	29.0	50.1	48.3
2	1213.6	815.10	32.8	28.0	48.8	45.7
3	1202.1	800.63	32.8	28.25	47.8	45.8
4	1184.4	805.77	31.8	28.5	47.5	46.5
5	1128.5	770.87	31.8	28.5	48.5	41.3
Average	1200.4	805.89	32.7	28.5	48.5	45.5

Heat Treatment "E"

(1 hr. at 850° C. and water quenched; drawn 1 hr. at 600° C. and air cooled)

Specimen No.	Work Done (Ft. Lbs.) Charpy	Work Done (Ft. Lbs.) Riehle	Elongation (Per cent) Charpy	Elongation (Per cent) Riehle	Contraction of Area (per cent) Charpy	Contraction of Area (per cent) Riehle
1	1162.7	893.10	28.3	26.0	61.8	61.2
2	1141.0	915.32	27.3	27.0	61.4	61.7
3	1210.0	914.42	29.3	26.5	61.4	61.5
4	1198.1	904.88	29.0	26.75	62.2	61.8
5	1237.7	906.65	29.8	26.5	62.6	61.6
Average	1189.9	906.87	28.7	26.6	61.9	61.6

Heat Treatment "F"

(2 hrs. at 850° C. and air cooled; drawn 1 hr. at 600° C. and furnace cooled)

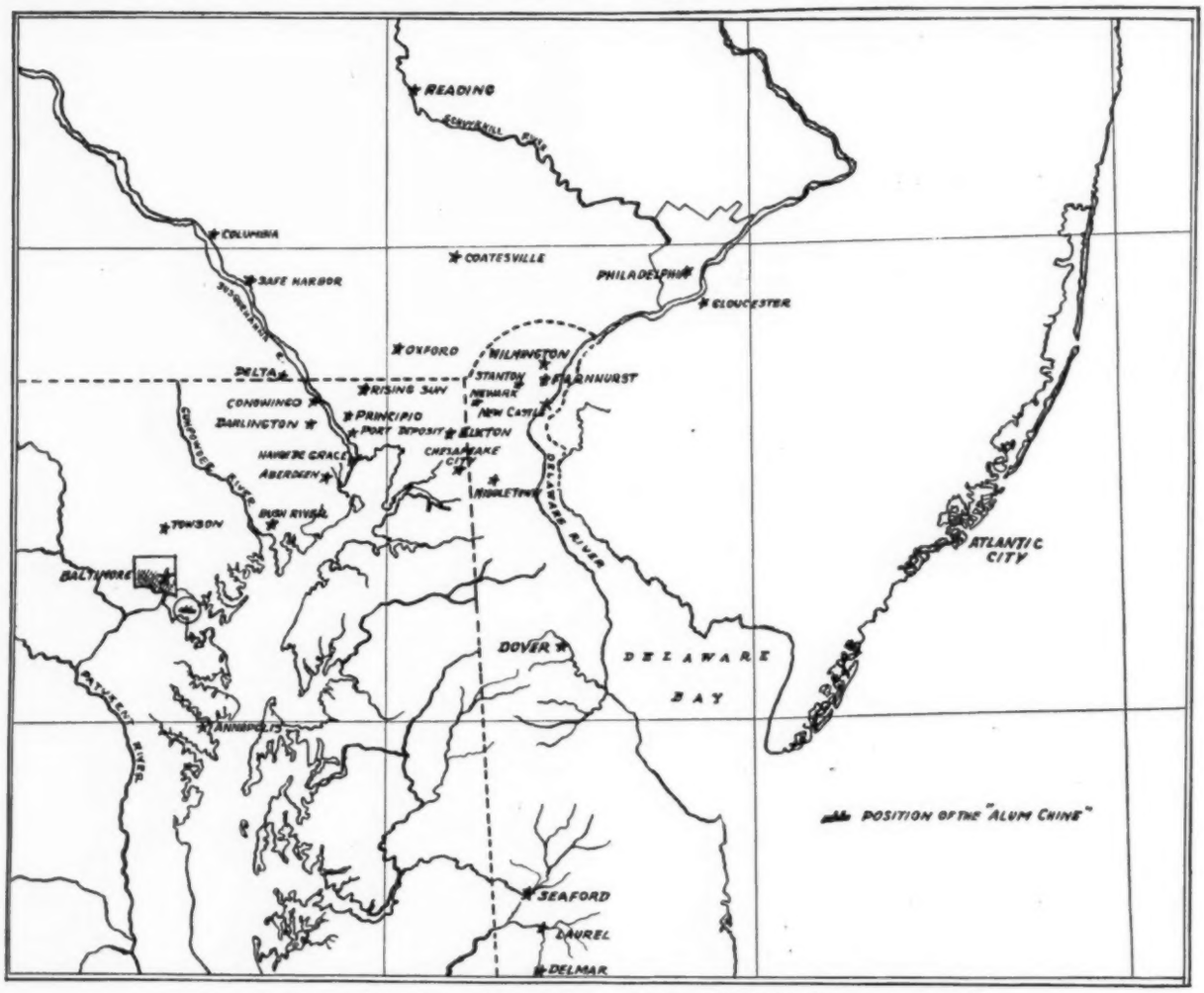
Specimen No.	Work Done (Ft. Lbs.) Charpy	Work Done (Ft. Lbs.) Riehle	Elongation (Per cent) Charpy	Elongation (Per cent) Riehle	Contraction of Area (per cent) Charpy	Contraction of Area (per cent) Riehle
1	1259.9	876.88	32.2	27.75	52.7	49.1
2	1186.2	857.76	30.3	27.75	52.2	49.1
3	1208.0	860.44	31.2	27.0	51.0	51.1
4	1208.0	862.66	31.5	28.25	52.2	50.9
5	1253.8	878.88	32.7	28.8	52.1	52.5
Average	1223.2	867.32	31.6	27.9	52.0	50.5

Wave Distribution at the Alum Chine Explosion

By

DR. CHARLES E. MUNROE

ON March 7, 1913, at 10.45 a. m., an explosion occurred on the British freight steamer *Alum Chine*, then lying just inside of Hawkins Point, at the entrance to the harbor at Baltimore, in 36 feet of water. This vessel was chartered to transport coal and dynamite to the mite. The dynamite was packed in cartons and these in cases. Each case contained 50 pounds of dynamite. The total weight of dynamite to be shipped was therefore 600,000 pounds, or 300 short tons. The explosives had been brought from the factory by rail some time in advance



Map showing localities from which effects of "Alum Chine" Explosion were reported

Canal Zone, Panama, the dynamite to be discharged at Cristobal and the coal at Port Limon. The *Alum Chine* was a single-decked steel vessel of 1,767 tons gross burden, and 16 feet draught. Some 2,000 tons of bituminous coal had been taken aboard when the stowing of the dynamite began.

The dynamite cargo consisted of 7,000 cases of 45 per cent and 5,000 cases of 60 per cent potassium nitrate dynamite. The dynamite was packed in cartons and these in cases. Each case contained 50 pounds of dynamite. The total weight of dynamite to be shipped was therefore 600,000 pounds, or 300 short tons. The explosives had been brought from the factory by rail some time in advance of stowing on the steamer and as the temperature had been low the dynamite was frozen. It was taken from shore without breaking bulk by placing the cars containing it on a barge and towing this barge alongside the *Alum Chine* when the cases were lifted to a chute, slid down into the hold, and stowed in the forehold on dunnage above the coal so that all of the dynamite was placed near to the water line.

The loading had been going on during the previous day so that on March 7 at 10.20 a. m., there was stowed on board the *Alum Chine* about 285 tons of the dynamite while about 15 tons remained in cars on the barge alongside.

At about this time the Second Mate of the *Alum Chine*, who was standing between 8 and 9 feet from the forward hatchway, heard a report "no louder than a pistol shot" and saw "smoke" issuing from the forward hatchway. Several of the stevedores below this hatchway testified to seeing a foreman grasp a cotton hook and drive it into a box of dynamite that they had had trouble in stowing into place and that immediately there was a report "like a pistol shot" followed by yellow smoke. This evolution of smoke from the forward hatch was observed by several different persons at different locations in Baltimore Harbor, one of them, familiar with operations at Sparrows Point steel works, likening it in color to the "blow" from a Bessemer convertor. These observations indicate the smoke to have been colored by nitrogen oxides from burning dynamite. In tests of frozen dynamite by exposure to friction a "crack" like that from a throwdown torpedo has been observed, followed by the burning of the dynamite. Whatever the source of ignition in this *Alum Chine* disaster it is undoubted that dynamite was set on fire, that some of the dynamite burned, and that the heat from this caused more or less of the remainder to explode.

Immediately that the report was heard and fire discovered the men on board ran for safety, some jumping overboard, but most dropping into the tug *Atlantic* lying by to tow the car barge, when its cargo had been discharged. Some one in passing cut this barge adrift.

The interval between the observing of the incidents above recorded and the final explosion was sufficient to permit the members of the crew and of the party of stevedores aboard, numbering upward of 70 men, to get to a relatively safe distance before the explosion occurred if they acted promptly. Nevertheless the casualties numbered some 32 killed or drowned and 60 injured. Some of these casualties occurred on the U. S. Collier *Jason*, lying to the west of the *Alum Chine* and less than one-fourth mile distant. The major part of the casualties occurred on the tug *Atlantic* due to the fact that when she had gotten some distance from the *Alum Chine* her captain, William E. Van Dyke, in an heroic effort to rescue two men that had been left on the *Alum Chine*, returned to the latter, took the men off, and was able to get but a short distance away when the explosion took place, destroying him and many of the persons on the *Atlantic*.

The effect of the blast was to shear the *Atlantic* off at the water's edge "as if cut with a knife" and to keel the *Jason* over more than 10 degrees of arc. The barge with its partly loaded cars was overturned, dumping the cars with their contents into the harbor, but it does not appear that any of this dynamite exploded. While considerable damage was done to the nearby collier *Jason* by the blast and by flying missiles, and while pieces of steel, approximately 150 pounds in weight, were thrown some 7 or 8 miles, yet the destruction wrought was less than might have been expected from so large a mass of explosive. While it is known that unexploded cartridges were thrown from the cargo, as some of these were picked up on the deck of the *Jason*, it is concluded that only a portion of the cargo of dynamite exploded and that it may not have been of the highest order of detonation.

Nevertheless the earth or air waves created by it were transmitted considerable distances, as shown by the following table giving the places from which effects were reported, with their distances and directions from the *Alum Chine*, and the records received from them on the day of the explosion:

Place	*Direction*	*Distance (Miles)*	*Remarks*
Baltimore, Md.	NW	4-8	The City Hall vibrated and dust was shaken down throughout the building. The doors of the sanctuary at the Cathedral were shaken open and it was feared the ceiling of the Cathedral was about to fall. At McCoy Hall, Johns Hopkins University, there was a feeling that the windows were being pushed in by a slight impact and there was also a slight thud heard. "The effects of the explosion were felt but to a comparatively slight extent in the northwestern portion of the city while pronounced shocks were felt in the southern, eastern and northeastern sections."—*Baltimore Sun.*
Towson, Md.	NW	12	Only a slight tremble. Few in this direction knew of an explosion until they read of it in the papers.
Columbia, Penna.	N	57	Brought terror.
*Delta, Penna.	NNE	37	Windows broken. "All the doors and windows went out. The report was loud and distinct. A roar was followed by a roll. The cloud of smoke was seen by several persons."—*Baltimore Sun*, March 8, 1913.
*Safe Harbor, Penna.	NNE	51	Same as Delta.
*Darlington, Md.	NE	32	Same as Delta.
*Conowingo, Md.	NE	39	Same as Delta.
*Rising Sun, Md.	NE	40	Same as Delta.
*Oxford, Md.	NE	49	Same as Delta.
Coatesville, Penna.	NE	63	Rattled windows in High School building.
Reading, Penna.	NE	86	Felt.
Bush River Neck, Md.	NEE	23	Many houses shaken and inmates badly frightened.

Place	*Direction*	*Distance (Miles)*	*Remarks*
Aberdeen, Md.	NEE	28	Houses shook. Four windows broken and one blown into room, cracks in walls enlarged, furnace in cellar moved and children thrown into a panic in High School building. It had to be repaired before being again fit for occupancy.
Havre de Grace, Md.	NEE	33	A plate glass window, 9 x 14 feet, in Lyon's Pharmacy was demolished. Houses were rocked, windows and dishes shaken from shelves.
Port Deposit, Md.	NEE	35	Glass broken. Molders in Bibb's foundry ran to the open. Colored population turned out *en masse* and offered prayer in the streets.
*Principio, Md.	NEE	35	Same as Delta.
Chesapeake City, Md.	NEE	42	Doors and windows rattled, houses shook and some plaster cracked. Trembling lasted one-half minute. Inhabitants ran from their homes.
Elkton, Md.	NEE	47	Judges, attendants, witnesses, etc., rushed from the Cecil Co. court house, teachers and pupils from the various schools. Felt by passengers of moving P. R. R. train coming into town.
Newark, Del.	NEE	54	Shock caused alarm among students at Delaware College. Believed to be an earthquake.
Stanton, Del.	NEE	61	Houses rocked.
Newcastle, Del.	NEE	61	A number of dwellings almost shaken from their foundations. (Believed due to explosion at Carney's Point.)
Wilmington, Del.	NEE	67	Shaken from end to end. Window panes broken and other damage done. Supposed to have been an explosion in the duPont mills at Wilmington. Train men on both P. R. R. and B. & O. R. R. felt the shock.
Gloucester, N. J.	NEE	90	Distinctly felt.
Philadelphia, Pa.	NEE	92	Caused windows to rattle. Small pieces of furniture shaken and overturned.
Middletown, Del.	E	47	A number of dwellings almost shaken from their foundations.
Dover, Del.	E	53	State Capitol badly shaken, causing a temporary adjournment of both houses of the Legislature, then in session, and Speaker Holcomb, of the House, to declare "That must have been an earthquake." Shock lasted 10 seconds. Fearing that the foundations of the building had been damaged a hasty survey was made, which disclosed none, before business was resumed by the Legislature.
Farnhurst	E	62	The 400 inmates of the Delaware State Hospital for the Insane and the 100 in almshouse adjoining were badly frightened.
Atlantic City, N. J.	E	104	Marked effect noted.
Seaford, Del.	SE	64	Mistaken for earthquake.
Laurel, Del.	SE	69	Houses rocked and hundreds rushed into the street fearing the houses would collapse.
Delmar, Del.	SE	74	Reported. "In almost every town in Delaware window panes in dwellings were broken."—*Baltimore Sun*, March 8, 1923.
Annapolis, Md.	S	18	Jarred. Crash and movement such that people rushed to the open.

These locations are plotted on the map.
*All in a zone of about 70 miles from Port Deposit, Md.

Starting from the arrow marking the location of the *Alum Chine* just inside Hawkins Point and off the Quarantine Station it is observed that the effects of the explosion were noted as far south as Annapolis, Md.; southeast, Delmar, Del.,; east, Atlantic City, N. J.; northeast, Philadelphia and Reading, Penna.; north, Columbia, Penna., and northwest, Towson, Md. Reports were received from but two places to the N.W., one only from locations to the S., and none from those to the S.W. and W. The most continuous effects reported were on the N.E. line to Philadelphia and up the valley of the Susquehanna river. The report from Dover, Del., indicates the effect to have been quite severe to the east.

It has been stated that the dynamite on the *Alum Chine*

was stowed at about the water line. With a view to ascertaining how the vessel was "pointing" at the time of the explosion information was sought from official sources. The Chief of the Weather Bureau gives the record for its Baltimore office at 10:30 A. M., March 7, 1913, as: temperature 20°, sun visible, wind velocity 10 miles per hour, wind direction (from) northwest, and adds the following extract from the records:

> "The explosion of a vessel, the *Alum Chine,* loaded with dynamite, in the harbor of Baltimore, Md., made a record on the barograph sheet at 10:45 A. M. A forcible puff of wind was felt at the window by the messenger boy immediately after the explosion. Dust was blown in the fourth story windows of the custom house."

The Acting Director of the U. S. Coast & Geodetic Survey states that "the tide at Hawkins Point at 10:30 A. M. on March 7, 1913, was almost low water." "On this day, the tidal conditions were very much disturbed because of the fact that strong northwest winds obtained during March 5th, 6th and 7th." After rehearsing normal current conditions he adds: "Therefore, at 10:30 A. M., the S. S. *Alum Chine* would have been heading northwesterly. However, owing to the fact that the tidal conditions were very much disturbed, it is impossible to state exactly, or even approximately, what current conditions obtained inside Hawkins Point on March 7, 1913. It is probable, however, that because of the normally weak tidal currents at this place, the strong winds caused the vessel to head in the direction of the wind."

On behalf of the Chief of Engineers, the District Engineer of Baltimore states: "At the time of the explosion the steamer was anchored near the main ship channel about one-half mile north of Hawkins Point in Baltimore Harbor." "Just before the explosion a strong northwest breeze was blowing and the *Alum Chine* was heading into the wind. The examination of the wreck made after the explosion showed the steamer lying on an even keel with the front end blown off, the stern still intact, and the wreck headed about west-northwest." "There are no data in this office as to the relative positions of the *Alum Chine* before and after the explosion, but it seems probable that the vessel was driven some distance astern by the blast and lay on the bottom with the axis in the same general direction as before the explosion."

Another report on the condition of the wreck states that "the explosion blew off the front end of the vessel, turning the sides out practically at right angles to the line of the hull, but not destroying the rear of the vessel."

When an explosive detonates the products of the reaction are projected into surrounding space at high velocity and a wave motion, analogous to that of sound, is imparted to the surrounding media. In fact, Le Conte* has shown the resemblance of this wave motion to that of sound to be complete even to its capacity to cast shadows. With the *Alum Chine,* situated as it was, when the explosion occurred such wave motions would be set up in the circumambient air, in the water in which the vessel was floating, and in the earth beneath it, each with a different rate of propagation as is also true for sound waves with a change of medium. †

From the reports cited above it is fair to conclude that at the moment of explosion the *Alum Chine* was heading to the northwest or west-northwest. An effect of the explosion undoubtedly was to raise the bow of the vessel, depress the stern and, by the recoil, drive the stern of the wreck under water with the result that the blast from the explosion in the bow would issue at an elevated angle and into the eye of the wind. Shot thus into the wind the "blast" of explosion products and stream of impulses set up in the air by the explosion, would be diverted from its course, a part, in this case, being deflected toward the northeast and other portions being in part reflected to the northwest and in part, perhaps after being in some measure completely overturned in its onward course, borne on to the east, southeast and south. Were these the conditions that obtained the air waves traveling to the northwest would tend to pass over Baltimore and Towson to descend in the valley of the Susquehanna. I have elsewhere shown that air waves from explosions behave in this manner‡ so that even nearby eyewitnesses to an explosion of tens of thousands of pounds of powder heard no report though persons 15 miles away did.

As the cargo of explosive was stored in the forehold near to the water line and (by theory) the bow of the vessel rose as the explosion took place, the effect upon the water, and upon the earth, which was at least 20 feet below the vessel's keel, must have been slight and any water or earth tremors produced must have been quite feeble. It is my opinion that, while Baltimore and Towson and perhaps even Dover, were affected by an earth tremor, most of the effects reported as produced at a distance were produced by air waves. It is interesting to note that the region on the line from Aberdeen to Philadelphia has been also thrilled by large blasts fired at the Aberdeen Proving Ground.

* On sound shadows in water. John Le Conte. American Journal of Science [3], v. 23, p. 27 (1882).

† Rate of earth tremor caused by explosion at Flood Rock. Henry L. Abbot. Ann. Rept. of Chief of Engineers f r 1886. Appendix E pgs. 691-717. Determination of velocity of explosion waves of small amplitude in sea water. Variation of velocity with temperature. A. B. Wood, H. E. Browne and C. Cochrane. Proc. of Royal Society [A], v. 103, 284-303 (1923).

‡ Zones of silence in sound areas from explosions. Charles E. Munroe. Prof. Memoirs, Corps of Engineers, U. S. A. v. 10, pgs. 253-260 (1918).

Scientific Apparatus Makers Endorse Defense Plans

Manufacturers of scientific apparatus in the United States, upon whom the proper design and production of ordnance matériel depends in great measure, recently adopted resolutions in favor of the industrial preparedness plans of the Government.

The resolution provided: "Whereas this association heartily approves the program of the present administration for the Army and Navy to keep in contact with the manufacturers of the country so that their needs can be met rapidly in case of war: *Be it resolved,* That we offer our full co-operation to those officers of the Army and Navy who are charged with preparing specifications for scientific instruments, laboratory apparatus and material so as to assist in making the apparatus as effective as possible and also designed so that it can be produced rapidly in case of emergency needs for large quantities."

This resolution was also approved by the Executive Committee of the Committee on Apparatus Makers and Users of the National Research Council at its recent meeting in Washington.

The German Long-Range Gun

PART I

By

H. W. MILLER

EVER since the famous long-range guns bombarded Paris from March 23 to August 9, 1918, discussions of these unusual weapons have appeared in print almost monthly, some of them giving a few correct details of the design, field operation, effect, etc., and others so lacking in accuracy as to be fantastic. It therefore seems pertinent to summarize here what has been learned about these mysterious and highly valued guns since they made their appearance on the Western Front, just two days after the German Armies began their famous final series of offensives which led to their downfall.

Some of the articles which have appeared to date on the long-range guns, and which seem worthy of consideration from the standpoint of accuracy, are, in the order of their appearance:

1. *Genie Civil* (French), Apr. 20, 1918—"Reconstitution and measurement of projectiles."
2. *L'Illustration* (French) Jan. 4, 1919—A general article on the effect of the bombardment.
3. *Journal of the United States Artillery*, Sept., 1919—By Col. E. M. Blake—Battery positions, counter measures.
4. *Mechanical Engineering*, Feb., 1920—By Col. H. W. Miller—The gun, carriage, projectiles, and the general effect.
5. *Munchener Neueste Nachrichte*, Mar. 29, 1920—The battery positions.
6. *West Deutsche Randschau*, 1921—Battery positions.
7. *Hearst's International*, Dec., 1921—By Col. Max Bauer—Design, process of construction, test, and use of the guns.
8. ARMY ORDNANCE, Jan.-March, 1921—By Major K. F. Adamson—Design and life of the gun, projectile, etc.
9. An article given in a German publication and partially reprinted in *Minneapolis Tidende* for Feb. 23, 1922, by Commander Walter Kinzel—Design and construction of the guns, battery positions, field service and withdrawal.
10. *"Hamburger Correspondenz,"* Apr. 13, 1922—Anonymous—History and fate of the guns.

In addition to the information printed in the above-named articles a number of interviews have been held with men of the German and Austrian services in which information has been secured. It will be obvious to the reader that a very serious attempt has been made by the Germans to keep the details of design of this weapon secret. They are fully justified in this for it is a real achievement. They sprung the guns as a complete surprise in the spring of 1918 and withdrew them into Germany in the summer of that year, retaining them until after the signing of the armistice when they began to cut them up and melt them in the furnace. They were obligated by the terms of the Peace Treaty to turn over one of the guns but they never complied with this order. No officer of the Allied armies has seen any of the guns and the several hundred men who worked on the design and manufacture of them and who operated them in the field have been muzzled so effectively that only the two listed above (7 and 9) and the few that will be mentioned herein have ever intimated that they knew anything about them or have described them in such a manner as to indicate that they knew what they were talking about.

Motive for the Construction of the Guns

It has probably been the natural assumption that the guns which go by the name of the Long-range Guns were constructed especially for the bombardment of Paris. There is no record to the effect that any other place was shelled by these guns, so the assumption would be a natural one. Apparently this was not strictly the case, however.

"Long-range guns carrying up to twenty-five miles or even a bit more were no novelty in the navies of the world when the World War broke out, but a range of twelve miles appeared sufficient for all purposes of land warfare." (7.)

"Trench warfare required among other things a weapon which the army did not possess, viz., a very heavy flat trajectory gun of the largest caliber and very longest possible range. It was no longer a case of attacking fortresses and battering their camouflaged concrete and armored structures to pieces by heavy high-angle fire. It was now a question of reaching out a few dozen kilometers behind the lines, taking rear communications, depots, camps, staff headquarters, trans-shipment stations, railway stations under fire, harassing and rendering uninhabitable large towns and troop concentration points far behind the front, and pushing the enemy's safety zone as far back from the fighting troops as possible.

"Rear Admiral Rogge, chief of the department, set the example and we followed it, and they strove at Essen to emulate us. And the results were not lacking, for the first 28 centimeter long range gun was in position opposite Verdun a few months after the outbreak of the war. and others followed shortly after. Each new gun showed an improved construction in the bed plates of the gun carriage, loading apparatus, or ammunition.

"The desire to increase the range of heavy naval guns arose very soon after the beginning of the trench warfare of unhallowed memory. There were certain targets a long way behind the rigid front which it was tempting to take under heavy fire now and then. Our aerial attacks often showed very good material results, but the aviators were always reported long before they had reached their objective. An entirely different moral effect could be obtained by making distant main strong points, harbors, etc., feel that they could be bombarded by heavy guns at any time of the day or night without previous warning.

"Nothing much could be done with a range of about thirty-five kilometers, which was the maximum distance

that our heaviest naval guns could then carry. It was necessary to get more range from the guns and at least reach Dunkirk, which was about forty-five kilometers distant from the westermost heavy batteries in Flanders.

"This task was finished very quickly. A hail of 38 centimeter shells fell on Dunkirk for the first time on April 28, 1915, and the town was never free from bombardment after that date. It was soon learned that the great harbor traffic of this channel port, so important in bringing up men, ammunition, and supplies, was almost completely paralyzed." (9.)

"The navy had already made considerable progress along the line of extreme ranges. This too was largely the work of Rausenberger, who, with the assistance of Admirals Rogge and Gerdes, had some time earlier constructed for the new dreadnaughts a thirty-eight centimeter cannon which was the peer of any ship's gun in the world. After certain changes in the carriage some of the guns had been brought to the front in Flanders, and the enemy was unpleasantly surprised when shells began to fall in the city of Dunkirk. . . . This range served our purposes for some time, but eventually our enemies readjusted their dispositions accordingly, taking their staffs and rest quarters farther back and entraining and detraining their troops at railway stations outside the reach of the 38 centimeter guns." (7.)

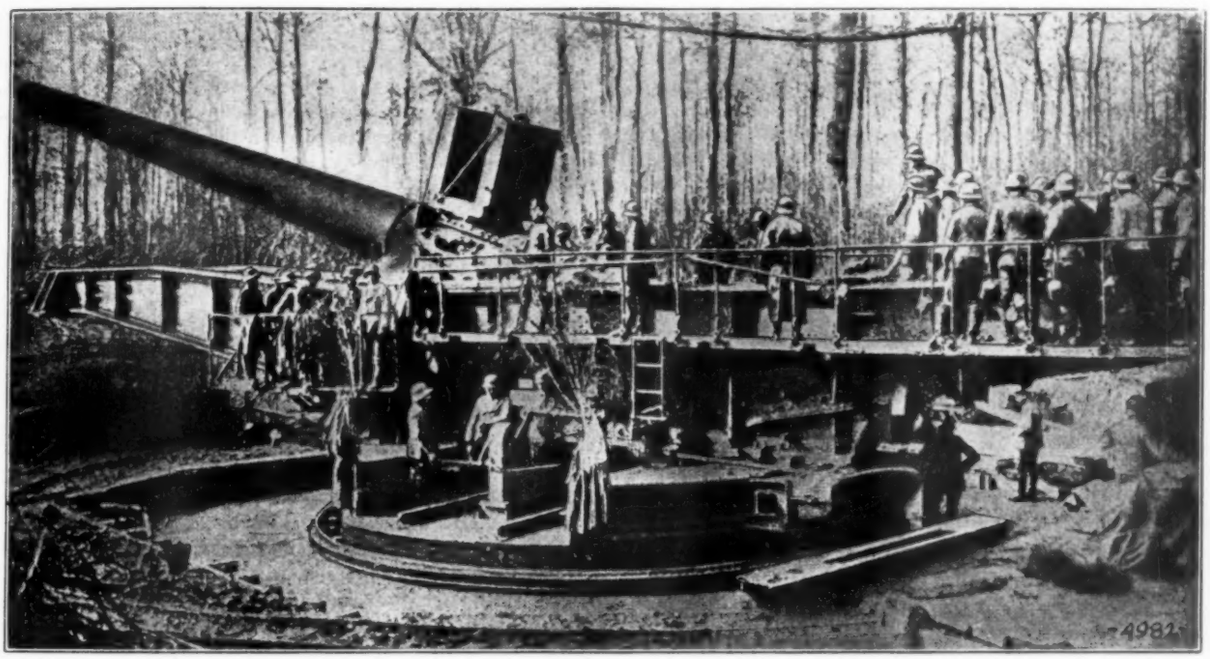
"It was possible in 1917, with the aid of other and especially efficient guns to take St. Omar, and Doullens, the enemy's main points of support and railway junctions, under fire from the vicinity of Cambrai at the distance of sixty-two kilometers. The experiments which led up to this success offered much that was surprising and highly interesting regarding the relationship between height and length of trajectory.

"To an inquiry in the spring of 1916 as to whether the Army High Command would consent to appropriations of money, materials and forces for the construction, probably possible, of a gun of 100 kilometers range . . . General Ludendorff, usually so brief and cool in his writing, replied with evident warmth and encouraged us to carry out the work. . . . *We had sufficient ground to work on to enable us to calculate and deduce that it could be done.* We had most thorough and expert assistance in the realization of the idea in the technical management of the artillery department of Krupps. We began the preliminary work and calculations at full pressure.

"After we had worked three-quarters of a year, Ludendorff surprised us with a brief telegram: 'Please take range of 120 kilometers instead of 100 as basis for future work on long-range gun.'

"Finally we reached the stage at which it was possible to make the first test with the long-range gun at the firing range." (9.)

The first trials were failures. After the projectile had been fitted "with the new point and iron guide ring," the gun was tested again. . . . This time "the shell fell exactly where our calculations had shown that it should fall. The problem was solved. And then for the first time the idea of the bombardment of Paris popped up. Not a soul had thought of it before; the French railway lines and harbors had been in our minds." (7.)



The Long-range Gun in Action

The indications from the above quotations are that the Germans strove constantly from the beginning of the war to produce guns of greater and greater range in order that they might reach farther and farther back of the Allied lines, even to the larger railway centers and harbors. In developing these guns they kept constantly in mind the interesting "relationship between height and length of trajectory." Their calculations indicated that if a projectile could be given the initial velocity of approximately 1,600 meters (5,250 feet) per second it would traverse the distance of 72 miles if started at an elevation of 55 degrees, because during most of its period of travel it would be passing through atmosphere of such rarity as to oppose relatively little resistance to its flight and cross-currents of air would have relatively little tendency to cause the projectile to drift off its theoretical path. Vigorous investigating and experimenting made them certain that such a

muzzle velocity could be attained. This it was that led them to suggest the 100 kilometer gun.

The relationship between height of trajectory and range for extreme muzzle velocities was not known to the Germans alone. In the *Scientific American* for April 8, 1916, Col. Alston Hamilton published an article entitled "The Extreme Ranges of Modern Guns" in which he included two tables giving ranges, heights, and time of flight for various muzzle velocities *in vacuo* and in atmosphere. He gave the maximum range for a muzzle velocity of 5,000 feet per second as 147 miles *in vacuo* with a height of trajectory of 37 miles. The extreme range for the existing 16-inch gun at a velocity of 4,000 feet per second in atmosphere was given as 85 miles with a height of 22 miles. The theory was therefore quite generally known. Practical methods for attaining such muzzle velocities, however, were not.

Colonel Bauer says that no one had in mind the idea of bombarding Paris. On the other hand, Commander Kinzel says in discussing the proposed range of 100 kilometers: "Our most advanced trenches were ninety kilometers from Paris at that time." Later, on receipt of the telegram from General Ludendorff instructing them to take 120 kilometers as the basis of future calculations, he says: "That was easy to read and understand. The retreat to the Siegfried position had been decided upon in the meantime, and our lines moved from 90 to 110 kilometers from Paris."

Apparently then one may take his choice of the direct motives for the construction of these unusual guns. There seems good reason to believe that they were proposed and agreed upon primarily for the purpose of bombarding the larger cities, railway centers, harbors, and larger troop concentration centers far back of the lines, and that Paris, among all of these objectives proved so much more enticing than the others that it received the full attention of all of the first few guns constructed.

The Design and Construction of the Gun

In the research work incident to the design and construction of the guns which Commander Kinzel says bombarded St. Omar and Doullens from near Cambrai at a range of about sixty-two kilometers, the Germans developed practical methods of attaining muzzle velocities far in excess of the usual. According to information secured by the American Army Commission composed of General Wheeler, Colonel Hubard, Dr. Cottrell, and Captain Schaller, on their visit to the Skoda Works at Pilsen in May, 1919, the German investigations showed the following relation between muzzle velocity and elevation for maximum range:

Muzzle Velocity		Elev. for Max. Range
750 m.s.	2460 f.s.	42 degrees
850 "	2790 "	50 "
900 "	2950 "	52 "
1600 "	5250 "	55 "

NOTE.—No tests were made at velocities greater than 1,600 meters per second, but the investigators felt that no increase in range could be secured at elevations greater than 55 degrees, no matter what the muzzle velocity.

The guns having a range of 62 kilometers had evidently been already designed and these calculations indicated that the difficulties involved in the construction of a 100-kilometer gun were not insurmountable. The instruction given by General Ludendorff to increase the range to 120 kilometers must have caused the designers no end of trouble. When one remembers that to increase the speed of a boat from 20 to 25 knots it is necessary to double the power, and to increase it from 25 to 30 it is necessary again to double the power, it can be appreciated what was involved when orders were given to increase the range of the proposed great guns by 25 per cent.

"It was only gradually that we realized the extra work this demanded, the calculations which had to be made afresh, abandoned and modified, and the difficulties entailed by increasing the range by twenty kilometers. . . . For a time we could only say that it *had* to be done; then gradually we had new ideas and found improvements to be made here and there, and when it seemed that the limit of efficiency of the materials had been reached it was boldly passed by utilizing new technical inventions.

"In the first place there were the problems of interior ballistics. Who could solve them fully? Who could watch the details of the process when the pressure in the barrel rose within a hundredth of a second from normal to 3,500 kilograms per square centimeter (67,000 pounds per square inch) . . . An idea had to be formed by means of calculations as to how the chamber of the gun should be made, what the size of the charge, weight of the projectile, and what kind of explosive should be used. . . . All former experiences gained at artillery ranges were brought forth and studied with painstaking exactitude. . . . A number of new and daring experiments were carried out. Many of them were encouraging." (9.)

The results of tests and calculations indicated that the economic diameter or caliber for such a gun was about 8 inches or 210 millimeters, the weight of the projectile about 120 kilograms (264 pounds), the powder charge 240 kilograms (525 pounds), and the powder chamber 3 meters (about 10 feet) long and cylindrical to receive the metal case in which the charge would be contained. To secure the velocity of 1,600 meters per second the gun would have to be at least 140 calibers long.

Shortly after the guns began their bombardment of Paris information leaked through to the effect that the guns had been made from 38-centimeter 45-caliber naval guns. General Wheeler was told by an Austrian engineer who had seen the guns in action, that they had been made from 38-centimeter 45-caliber naval guns. He was likewise shown three such guns in the Skoda Works which were said to have been in process of transformation into long-range guns at the time of the signing of the armistice.

"Tubes 12 to 18 of the German 38-centimeter quick-firing cannon, cal. 45, were utilized as a basis for the construction of the Paris guns. . . . There were therefore seven of these long guns in existence." (10.)

"The outer tube was already available: the 38-centimeter naval gun." (7.)

Tubes 1 to 11 were probably used on the carriage emplaced at the village of Luegenboom in Belgium for the bombardment of Dunkirk, and on the 38-centimeter railway carriages used by the Germans on various occasions for the bombardment of depots and cities at long heavy-gun ranges.

These 38-centimeter guns were lined with 140-caliber 210-millimeter tubes.

"A 20-centimeter tube was cast and inserted in the big gun, which took the place of the ordinary jacket. This was merely a matter of usual construction. . . . The only undesirable but unavoidable thing was that the inner tube, being naturally much longer than the jacket-gun, projected far beyond the latter's muzzle." (7.)

Herr Langner informs us that "the 38-centimeter gun was fitted with two tubes, the one 30 meters long and inserted in the gun and afterward rifled, and the other 6 meters long, unrifled, and attached to the end of the rifled tube." Another report to the Chief Ordnance Officer, dated

(*Continued on Page 122*)

Artillery Design

PART II

By

BRIG. GEN. COLDEN L'H. RUGGLES

Super-Guns

THE accompanying tabulation shows the Caliber Board requirements for super-guns. The requirements of the Board present no insuperable obstacles from an engineering standpoint and the program of design and development of these guns has been limited only by available funds.

The 8-inch gun referred to has been designed, but not yet manufactured. It will be fired from the same carriage as the ideal 12-inch, 20-caliber howitzer which is to have a maximum range of 25,000 yards.

8-inch Gun and Railway Mount

As indicated, the 8-inch gun has not been constructed but its probable characteristics as designed are:

Length of gun in calibers 50
Weight of gun—without B. M. and band ..... 47,000 lbs
Maximum Range ..... 35,000 yds.
Weight of projectile ..... 240 lbs.
Weight of powder charge ..... 80 lbs.
Muzzle velocity ..... 2,850 f. s.
Loading angle ..... minus 5°
Firing angle ..... 20° to 50°

REQUIREMENTS FOR SUPER-GUNS

Caliber	*Guns*		*Howitzers*	
	8 or 10 inch	14-inch	12-inch	16-inch
Length in Calibers	50	50	20	25
Weight of Projectile	240—510	1,400	700 1,046	1,600
Maximum Range	35,000	40,000	25,000 18,000	30,000
Elevation	0° to 50°	0° to 50°	25° to 60°	25° to 65°
Traverse	360°	360° 15°	360°	360° 10°
Type of Projectile	H. E.	H. E.	H. E.	H. E.
Time for Occupying Position—				
Prepared	----------	1 hour	----------	----------
Unprepared	1 to 4 hours.	8 hours	1 hour	----------
Maximum Rate of Fire	1 shot, 2 minutes	----------	----------	----------
Gauge of Track	Standard, 60 cm.—24-inch.	Standard 12-inch	Standard	Standard

Ammunition for all cannon: Smokeless, flashless.
Related zone charges for howitzers.
Fuzes: Bore safe, instantaneous, and selective delay.

The 14-inch gun and mount specified by the Board have been constructed and are now at the Proving Ground for test.

The same is true of the 12-inch howitzer and mount.

The 16-inch howitzer with its recoil mechanism has been tested at the Aberdeen Proving Ground on a barbette carriage. This howitzer will be mounted on the railway mount constructed for the 14-inch, 50-caliber gun mentioned. No difficulty is anticipated in realizing the Board's requirements for this matériel.

Traverse on car ..... 360°
Total weight on rails ..... 240,000 lbs.
Maximum axle load ..... 42,000 lbs.
Emplacement: On track with steel I-beams and outriggers.

12-inch Howitzer and Railway Mount

The characteristics of the 12-inch howitzer and railway mount, Model of 1918, are:

Length of howitzer in calibers 20
Weight of howitzer, with B. M. and band ..... 49,239 lbs.

Maximum range, estimated	25,000 yds.
Weight of projectile	700 lbs.
Weight of powder charge	108 lbs.
Muzzle velocity	1,950 f.s.
Loading angle	minus 5°
Firing angle	20° to 60°
Traverse on car	360°
Total weight on rails	228,800 lbs.
Maximum axle load	40,900 lbs.
Emplacement	On track with steel I-beams and outriggers.

The 12-inch howitzer on its railway mount consists of a typical barbette carriage for seacoast artillery, mounted on a railway car, except that the base ring of the carriage is an integral part of the frame of the car, which is depressed between the trucks to lower the center of gravity of the mount. The recoil control-mechanism is of the latest hydro-pneumatic type for seacoast artillery. The gun and top carriage may be traversed 360° on the base ring in the ordinary manner.

Elevation is of the ordinary type. Elevating and traversing are done by hand power only. Since the carriage is to be fired at all angles to the track, outriggers are provided as shown to take the rearward thrust due to firing in whatever direction the car may be pointed and also to take the downward component of the firing stress.

To place the mount in firing position, steel I-beams are placed parallel to the center line of the track, one on each side, just outside the rails and on the ties. The carriage is then run over these beams and the frame of the car lowered by means of self-contained jacks until the entire weight rests on the beams and is taken off the trucks. The outriggers are then placed in position and the gun is ready for firing.

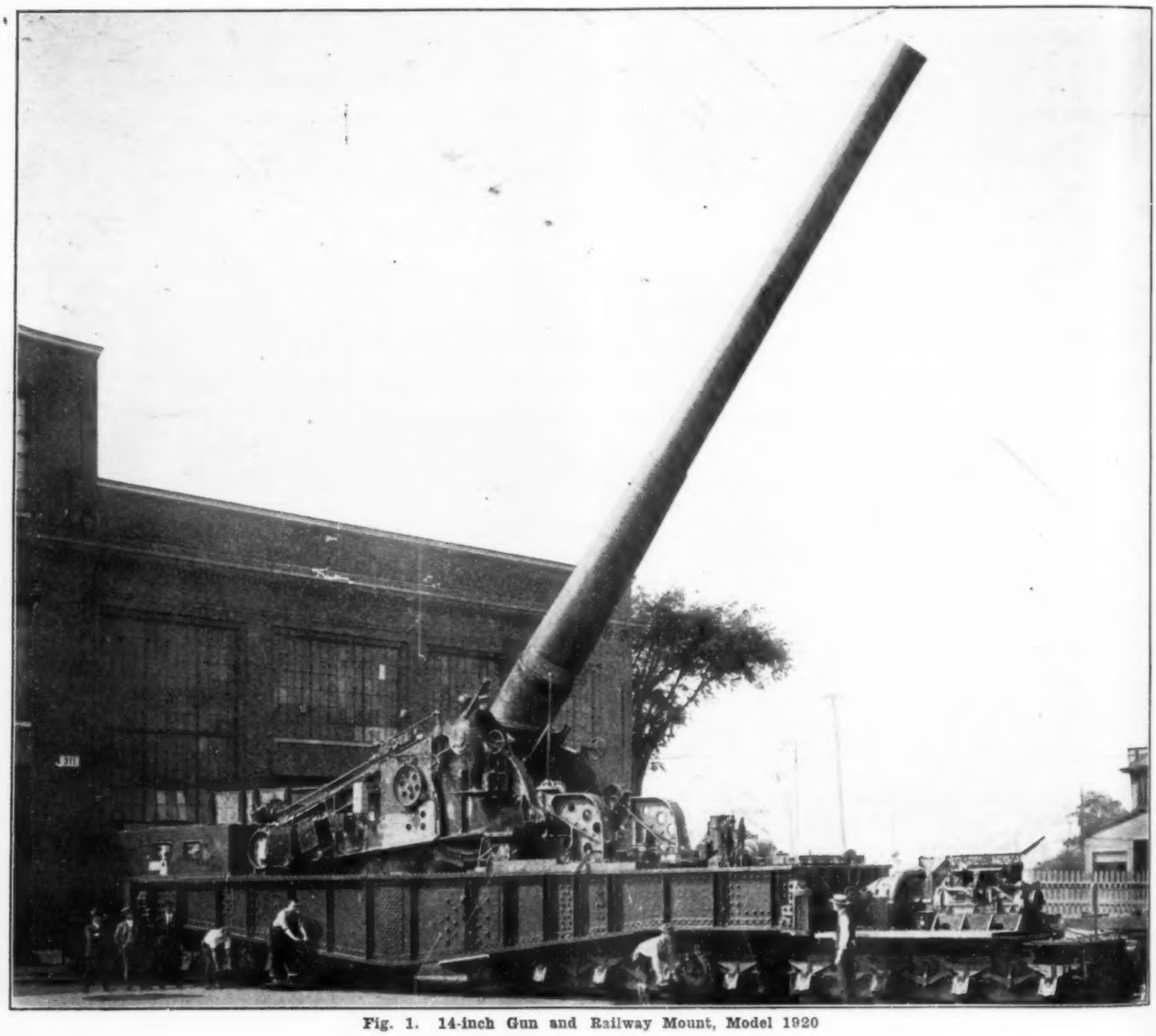


Fig. 1. 14-inch Gun and Railway Mount, Model 1920

14-inch Gun Railway Mount

The characteristics of the 14-inch gun railway mount, Model of 1920, now undergoing test are:

Length of gun in calibers	50
Weight of gun complete	223,782 lbs.
Maximum range for 1,400 lb. projectile	over 40,000 yds.
Maximum range for 1,560 lb. projectile	40,000 yds.
Weight of projectile	1,400 and 1,560 lbs.
Weight of powder charge	462 lbs.
Muzzle velocity for 1,400 lb. projectile	2,800 f.s.
Muzzle velocity for 1,560 lb. projectile	2,650 f.s.

Loading angle ---------- minus 7°
Firing angle ---------- zero to 50°
Traverse of top carriage ---------- 7°
Traverse of mount on permanent emplacement ---------- 360°
Total weight on rails, approximately ---------- 700,000 lbs.
Maximum axle load ---------- 48,000 lbs.
Emplacement—Temporary, on track with steel I-beams and outriggers; permanent, on concrete block.

Two built-up girders rest, in traveling position, on trucks. The top carriage is pivoted to a universal joint on the girders so as to permit of its being raised to its firing position or lowered to traveling position and also to be traversed right or left 3½ degrees.

The raising of the car to the firing position is effected by means of two screws operated through gearing by an electric motor on the front deck of the car, or they may be operated by hand. The lower ends of these screws have T-shaped heads which engage in lugs at the front of top carriage. When the top carriage is raised the proper amount, the cross beam is translated by hand gearing under the front of the top carriage to take the weight. The screws are then lowered out of the way. To lower the top carriage the operation is reversed. The recoil mechanism is of the latest hydro-pneumatic type. The elevating mechanism is of the ordinary seacoast type and elevation may be accomplished by hand or by power from an electric motor on the rear of the top carriage. The gun is traversed on the top carriage around the universal joint by hand through a set of gearing.

When this mount is fired on the permanent emplacement it is hauled over the emplacement and the whole carriage above the trucks is lowered by means of self-contained screw jacks until the pintle rests on a bed plate on the permanent foundation. Tap bolts are then screwed down into drilled holes in the bed plate of the permanent foundation. Two traversing rollers journaled in a transom between the girders will then rest on a base ring in the permanent emplacement.

The mechanism for lowering the carriage onto the permanent emplacement also takes the load off the trucks and the latter are then hauled out from under the carriage. Traverse through 360° on the permanent emplacement may

16-INCH HOWITZER RAILWAY MOUNT, MODEL 1920—CHARACTERISTICS

Length of howitzer in calibers	25
Weight of howitzer—complete	195,151 lbs.
Maximum range for 1,660-lb. projectile, computed	30,000 yds.
Weight of projectiles	1,660, 2,100 and 2,340 lbs.
Weight of powder charge, estimated—	
For 1,660-lb. and 2,340-lb. projectile	335 lbs.
For 2,100-lb. projectile	315 lbs.
Muzzle velocity for 1,660-lb. projectile	2,225 f.s.
Muzzle velocity for 2,100-lb. projectile	2,000 f.s.
Muzzle velocity for 2,340-lb. projectile	1,875 f.s.
Loading angle	minus 7°
Firing angle	20° to 62°
Traverse of top carriage	7°
Traverse of mount on permanent emplacement	360°
Total weight on rails	650,000 lbs.
Maximum axle load	45,000 lbs.

Emplacement—temporary, on track with steel I-beams and outriggers; permanent, on concrete block.

CALIBER BOARD REQUIREMENTS FOR ANTIAIRCRAFT GUNS IDEAL, TWO TYPES, LIGHT ANT HEAVY

	Light	*Heavy*
Caliber	About 3 inches	4.7 to 5 inches
Muzzle velocity	2,600 f. s.	2,600 f. s.
Elevation	80°	80°
Traverse	360°	360°
Projectiles—Weight not less than	15 lbs.	45 lbs.
Projectiles—High explosive, maximum ballistic qualities.		
Ammunition—fixed.		
Powder—Smokeless, flashless.		
Fuze—Mechanical.		
Rate of fire—To be maximum.		
Time of flight—To be minimum.		
Transport	Caterpillars, self-propelled or trailers.	Self-propelled caterpillars
Trailers to be provided for long, rapid hauls.		
Capable of sustained speed of	12 M. P. H.	8 M. P. H.

be accomplished by hand or motor power through gearing acting on the traversing rollers. In position on the permanent emplacement, the carriage is essentially of an all-around-fire seacoast type.

For use in the field where there is no permanent emplacement, steel I-beams are placed parallel to the axis of the track on which the pintle will rest. The carriage is then hauled over these beams and lowered as before until the pintle rests on them. The movement in this case is not sufficient to take the entire load off the trucks and to prevent undue vibration of springs wedges are inserted between journal boxes and the lower part of the truck side frames. The outriggers are for the purpose of preventing movement to the rear when the gun is fired on a temporary emplacement. They also take a part of the downward component of the firing stress.

Two loading cranes are provided for raising the ammunition from the ground and placing it on the loading stand on the car platform in rear of the breech. This stand has a slope of minus 7°, so that the projectile when started seats itself by force of gravity. The powder charges have to be rammed into the chamber.

16-inch, 25-caliber Howitzer

The foregoing tabulation gives the characteristics of the 16-inch howitzer and railway mount, Model of 1920.

Figure 2 shows the 16-inch, 25-caliber howitzer which is to be mounted on the 14-inch gun railway mount. As shown, the howitzer is mounted in its seacoast carriage. This howitzer with its elevating parts can be mounted bodily in the railway mount.

Antiaircraft Guns

The Caliber Board requirements for antiaircraft guns are given in the preceding tabulation.

A 3-inch Antiaircraft Gun Mount designed under the Caliber Board specifications and a self-propelled vehicle of the Christie type have been under test at the Aberdeen Proving Ground. Because of the extreme width, insufficient road clearances and defective design, test of the self-propelled vehicle has been discontinued for the time being, and the mount placed on a trailer which is drawn by a tractor. This trailer was designed for the 3-inch antiaircraft gun matériel, Model 1918, but the road and firing tests made to date indicate that a vehicle of this type will be preferable to the self-propelled vehicle. While the matériel has stood up under various tests, a new model is being designed that will be simpler in construction. It will be mounted on a trailer.

A 4.7-inch antiaircraft gun, mount and self-propelled vehicle are also under test at the Proving Ground. While difficulties similar to those mentioned in connection with

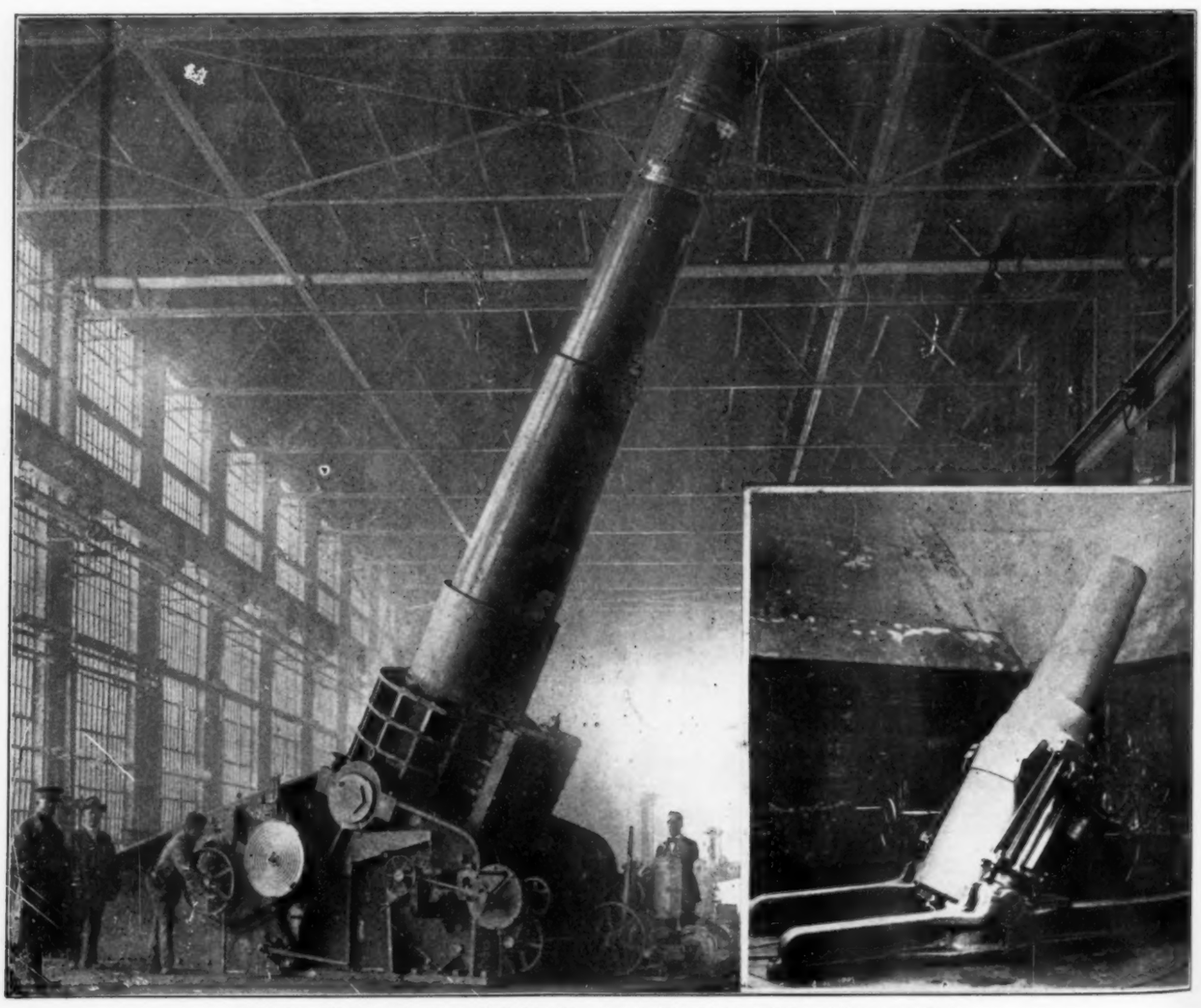


Fig. 2. 16-inch Howitzer of Today Compared with 12-inch Mortar of Pre-war Days

the 3-inch A.A. gun mount are being experienced with the self-propelled vehicle, the test is still being continued. As the 4.7-inch and the 3-inch A.A. mounts are built along the same general lines, the design of a new 4.7-inch antiaircraft mount will not be undertaken until tests of the new 3-inch have been completed.

The characteristics of the 3-inch antiaircraft gun and mount, Model 1920, are:

Length of gun in calibers	50
Weight of gun, complete	2,141 lbs.
Maximum vertical ordinate to point of burst	8,391 lbs.
Maximum horizontal ordinate to point of burst	7,707 lbs.
Weight of projectile	14.78 lbs.
Weight of powder charge	5.5 lbs.
Muzzle velocity	2,600 f.s.
Loading angle	0 to 80°
Firing angle	0 to 80°
Traverse	360°
Weight of trailer—approximate	10,000 lbs.
Total weight, trailer and mount complete	16,000 lbs.

Fig. 3 shows the left-side elevation of the carriage in firing position, with outriggers set and the folding platforms in position. The recoil system is of the hydropneumatic type. As the gun is trunnioned near the breech the muzzle preponderance is taken care of by means of two spring equilibrators. The traverse of the carriage is accomplished by handwheel and gearing on the left side of the carriage by the man operating the sight who likewise elevates and depresses the sight in order to keep it on the target. Lateral deflection is set off on the same side of the carriage and may be varied without disturbing the azimuth of the sight.

Elevation of the gun is accomplished by the handwheel and gearing on the right side of the carriage, the required amount of elevation being shown by a pointer registering on a drum in the case immediately above the handwheel. This drum receives its rotation by the action of the man at the sight in keeping on the target and by the smaller handwheels on the right side of the carriage which are used to set off elevation corrections. The readings on the drum indicate the algebraic sum of the angle of site and elevation corrections.

A fan-shaped fuze range computer is located on the right-hand trunnion by means of which the fuze setting can be obtained when the altitude only of the target is given, the rest of the data being supplied automatically by pointing the sight at the target.

After the outriggers are set and the platform approximately leveled, the final leveling operation is done by means of concentric handwheels. The loading tray and fuze-setter are attached to the carriage. The loader and the semi-automatic breech mechanisms are pneumatically operated. These latter features have not given entire satisfaction and studies are under way to provide another mechanical means for doing this work.

The characteristics of the 4.7-inch antiaircraft gun and mount, Model 1920, are:

Length of gun in calibers	42
Weight of gun, complete	5,183 lbs.
Weight of projectile	45 lbs.
Weight of powder charge	12 lbs.
Muzzle velocity	2,600 f.s.
Loading angle	0 to 80°
Firing angle	0 to 80°
Traverse	360°
Weight of self-propelled vehicle	26,000 lbs.
Total weight, vehicle and mount	42,000 lbs.

Trench Mortar

The Caliber Board requirements for a trench mortar are:

Caliber, about 6 inches;
Weight of projectile, about 50 pounds;
Maximum range, about 4,000 yards;
Elevations from plus 40 degrees to plus 65 degrees;
Type of mounting such that elevating does not affect traversing, and vice versa;
Great simplicity in design because principal value of the trench mortar lies in cheapness and rapidity of construction in large numbers.

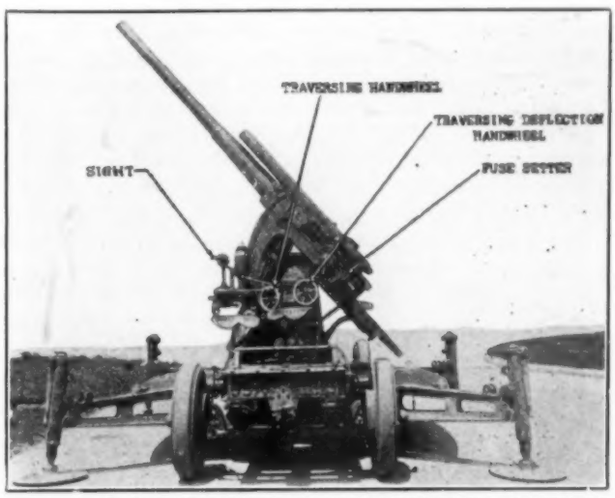


Fig. 3. 3-inch Antiaircraft Gun and Trailer Mount, Model 1920 E

The requirements as to range and caliber have been found difficult to fulfill in connection with the requirements as to simplicity in design, cheapness and rapidity of construction in large numbers. Preliminary studies indicated that to obtain a range of approximately 4,000 yards, a rifled mortar with controlled recoil is necessary, preferably of a breech-loading type. These considerations, and the necessity of providing a separate form of elevating and traversing mechanism, resulted in a type which might be considered as not fulfilling the requirements for cheapness and rapidity of construction in large numbers. However, the questions of simplicity of design and of cheapness are relative ones. While this matériel is complicated, in comparison with the Stokes mortar, it is really a very simple design and one easily produced, compared to any other rifled piece in the service.

A trench mortar designed under the Caliber Board requirements is now at the Proving Ground for test. To obtain the range required a velocity of 750 f.s. is necessary. The mortar recoils a distance of 18 inches on its carriage. This recoil is controlled by a poppet valve. It has spring return to the battery. It may be traversed 15° on either side of the center by the handwheel on the left side. The elevating handwheel is on the right side. When the mortar is elevated for firing, the latch connecting the cradle to the elevating arm may be released and cradle and mortar turned by the lever on the right side to a depressed position for loading. After loading, it may be elevated by the lever until the latch re-engages. The mortar and carriage can be separated into four loads, in order that it may be handled into and out of the firing position by man power. These loads vary from 395 to 481 pounds each. An axle and wheels are provided for traction. A pole is provided for horse draft and a shorter pole, with

lunette, for motor draft. At the rear of the mount in the traveling position a pintle is provided for attachment of an ammunition limber or other vehicle. A panoramic sight is mounted on the left side of the top carriage and a range drum is mounted on the elevating arm.

Tractors

The Caliber Board requirements for tractors include a small model, now termed the power cart, to carry a cargo of about 200 pounds and to be operated by a man on foot; a ¼-ton tractor to be capable of carrying a cargo of about 500 pounds, and to be used for reconnaissance purposes to replace the horse; a 2½-ton and a 15-ton tractor in addition to the 5 and 10 ton tractors that were manufactured during the war. However, since the report was approved it has become evident that the 5-ton tractor is too light and the 10-ton tractor too heavy to be used with the new corps artillery and therefore it has been decided to design an intermediate size, the 7½-ton tractor, so that the series of the future will be 2½-ton, 7½-ton, 15-ton, instead of 2½, 5, 10 and 15 ton, as outlined by the Board.

Much progress has been made on the development of a tractor for divisional artillery nominally rated as the 2½-ton tractor. Two experimental models were constructed and tested until the basic faults had been well determined, and then rebuilt and tested further. One of these has been tested with fairly satisfactory results over 1,000 miles at the Proving Ground since rebuilding. The other model has been run 100 miles to get it into proper adjustment and shipped to Fort Bragg for test by the Field Artillery Board.

The corps tractor has not yet been completed. This model has been designed with a view to testing the principle of a combined wheel and tracklaying tractor. For the first tests the tractor will probably be equipped with a conventional caterpillar track. Later, when a promising type of track has been found by other experiments that are under way, it is expected to test the convertible wheel caterpillar principle thoroughly.

Two models of the Army, or 15-ton tractor, are being constructed; one of these is almost completed. It has a conventional caterpillar track. The other model will have an experimental track and method of suspension. All of these tractors are being designed with a view to obtaining a speed of about 12 miles per hour.

The ideal tractors which the Ordnance Department is trying to develop will require a comparatively long time for production in quantity after war is declared. During this time it will be necessary to supplement our existing tractors by the purchase of commercial types which can be readily obtained in large quantities. For this purpose a number of commercial tractors are now under test. The Fordson is the commercial tractor in largest production at the present time and, while it is not suitable for divisional artillery purposes when equipped with ordinary wheels, tests of this tractor equipped with a commercial adapter made by the Hadfield-Penfield Company are so promising that several units have been purchased for test by the Field Artillery Board. There are also under test the Best 30 and the Holt T-35 commercial tractors. Both of these are promising, although they cannot be obtained in the same quantities as the Fordson.

Trailers

The Caliber Board requirements call for 1½ and 3 ton caterpillar trailers to replace caissons for motorized artillery, and in addition to these types, a lighter model, the ¾-ton caterpillar trailer, is under development. None of the vehicles so far produced with the conventional caterpillar track is satisfactory. The conventional track is very heavy for a trailer and does not possess sufficient durability at high speeds on hard roads. As has been stated experiments are now under way to improve the type of track for all caterpillar vehicles, and if successful, the improved track will materially aid in the development of an ideal caterpillar trailer.

The ¾-ton caterpillar trailer is a wheeled vehicle primarily made up of many of the parts of the Dodge truck, such as springs, steering knuckles, etc. It has four solid rubber-tired wheels and is completely spring-mounted. The vehicle is steered by the draw-bar. The caterpillar track on this vehicle is of the Chase type, and can be placed over the wheels for running across country and removed therefrom when the trailer is to be towed over good roads.

It is probable that the best solution for the trailer problem is to develop trailers utilizing as many parts of commercial trucks as possible, including the springing of the trucks on the axles. These trailers should be provided with six wheels instead of four as in the case of the truck and of course should be without power plant. For operation over good roads the trailers would run on their wheels; for operation across country a caterpillar track of light design would be placed on the four rear wheels, two on each side, and a band of the same kind of track placed over the front wheels. Steering would be by the draw-bar.

Divisional Tractor

Two pilot divisional tractors, Model 1920, were built. One is under test at the Proving Ground and the other is under service test at Fort Bragg.

Being designed for a sustained speed of 12 miles per hour and a maximum speed of 16 miles per hour the tractor has a minimum of unsprung weight, and great flexibility in the suspension. There are four speeds forward and two in reverse, in order to get a very low speed when the maximum draw-bar pull is desired under adverse conditions. The weight is about 7,200 pounds. It has a 16-valve White, 60 horsepower engine. Two pairs of track rollers on each side are mounted on caterpillar beams, which in turn are attached to leaf springs in what amounts to another set of equalizers, so that the track can conform to uneven ground very readily. The front idler is also sprung. The rear drive is an internal gear, inside of the sprocket, driven by a pinion at the center, through idlers, thus making it possible to seal and lubricate it very effectively. The track shown here has given excellent service, having been run 1,100 miles with little wear. It has depressions which when sunk into soft ground materially increase the action, but on good roads there is ample flat, smooth surface so that the road surface is not marred. However, in exceptionally bad places extra grousers can be attached, but only a few are required. Refinements in some parts of the design are still necessary.

Army Tractor

The Army tractor, Model 1921, has the conventional caterpillar track, but the leaf springs which support the weight on the track rollers also form an equalizer to reduce stresses on and guide the rollers on the track. The high box-like frame is for the purpose of providing a

watertight compartment for the power plant to permit the tractor to travel in water not over seven feet deep. Two winches are provided on the front end. On good roads the tractor can develop a speed of about 12 miles per hour. The engine develops 180 horsepower at 1,200 revolutions per minute. One pilot, which is being constructed, will weigh at least 20 tons.

The type of track and suspension for the Army Tractor, Model 1922, which is similar in other respects to the Model 1921 tractor, is what is known as the "Roadless" type of track. It is otherwise known as the cable suspension type from the fact that a wire rope was first used where the chain is shown. This type of track originated in England, and is being applied to commercial vehicles in this country by the Roadless Patents Holding Company.

The truck rollers are mounted on bogies, connected by shackles to the vertical plungers, on top of each of which a small idler sprocket engages the chain that alternately passes over these plungers and under similar sprockets on the "truck frame." The chain is anchored at the rear end of the frame, and connected to a coil spring at the front end. Thus the bogies can pass over uneven ground, and still bear their share of weight, and yet only a comparatively small spring is required. The track has a monorail on which the rollers run, the upper surface of the rail being a semi-cylinder, and the rollers are formed to fit the cylindrical shape. The joints between track shoes are formed on the ball-and-socket principle so the shoes have a limited motion in all directions relative to each other. This makes it practicable actually to curve the portion of the track engaging the ground slightly sideways, and the bogies are so swung that they can travel on this curve.

The transmission on this model does not deliver the power to the tracks through independent gear trains as on former tractors, but through a controlled differential that will drive each track at different speeds for steering purposes. The tractor will not turn in place, but it can turn on the arc of a circle as does a truck or automobile, the minimum radius being about 30 feet. When driving straight ahead the differential drives both tracks at equal speeds. For steering, there are brakes for each side that are so geared to the differential that application of the brake on one side causes the tractor to turn in that direction. This construction will materially reduce the weight of the tractor, because the type of suspension and track permits of lighter parts.

¾-ton Trailer

In building up the chassis of the ¾-ton trailer caisson, made with the Chase type track assembled, many standard Dodge parts are used. The wheels have solid rubber tires and the rear pair are mounted so that they can be moved to adjust the tension on the track. The front pair are arranged for steering on steering knuckles when the track is not on the wheels, and under this condition the draw-bar is coupled to the steering knuckles. With the track on, the front wheels are locked parallel to the axis of the vehicle and steering by the draw-bar slides the vehicle around on the track as a sled. The vehicle weighs 1,425 pounds and a 1,500-pound load has been carried successfully. The large body is primarily to float the vehicle in water when loaded. However, tests have shown that there is only about 1½ inches of freeboard when in the water, which undoubtedly is not sufficient for safety.

1½-ton Trailer

In the design of the 1½-ton trailer caissons, the body is suspended on springs on an axle at the center of the truck frame, so the draw-bar supports the preponderance at the lunette. Obviously, if the load becomes unbalanced with reference to this axle, difficulty is experienced when attempting to limber or unlimber. The chains are for the purpose of fastening the body to the truck frames when desired, but in traveling these chains are not in use. This vehicle empty weighs about 4,700 pounds, so with its load of 3,000 pounds it is considerably heavier than the matériel it normally is to serve, namely, the divisional artillery.

Dodge Truck with Chase Track

Fig. 5 shows a Dodge truck with Chase track that has proven very successful for cross-country work. The extra pair of wheels are attached by a spring system to the

Fig. 5. Dodge Light Repair Truck With Chase Track

standard Dodge chassis, and the Chase track is assembled over the two rear wheels on each side. A band of similar track is fastened around each front wheel. With the omission of the power plant, and the shortening of the chassis permitted thereby, this vehicle would become a most satisfactory trailer. For high speed on good roads the tracks would be removed.

Artillery Ammunition

The Caliber Board requirements for artillery ammunition can be stated in general terms as follows:

(a) *Projectile.* Projectiles for guns should be designed to give maximum range, and for howitzers, except the light field howitzer, to give maximum bursting-charge effect. There are in addition specific requirements for interchangeability between gun and howitzer projectiles for certain calibers. In most cases there is also a substitute for the approved type for production reasons. This substitute is a cast type of semi-steel which can be produced in foundries.

(b) *Fuze.* Fuze requirements are that the fuze for high-explosive shell be bore-safe and that it be a selective-delay type; that is, capable of being set for either super-quick or for delayed action. In general, a super-quick and short-delay fuze is required for guns and a super-quick and long delay for howitzers. Time fuzes are required for shrapnel with the suggestion that the mechanical type be developed.

(c) *Powder.* Requirements for powder are that it be flashless and smokeless with the suggestion that the powder be made non-hygroscopic so as to be less affected ballistically by exposure to moist atmosphere. The make-up of charges is, in general, a normal and a super-charge for guns and an aliquot part zone charge system for howitzers.

Ballistic Experiments

In connection with the general study of projectile design, the Ordnance Department has underway tests at the Proving Ground, in which firings are made through a series of paper screens placed from a point close to the muzzle to a point several hundred yards distant. The holes made in the screens indicate the course of the projectile and the angle which its axis makes with the trajectory, usually referred to as "yaw." The orientation of this yaw can be determined also by measurement of the holes in these screens. In this way, the course of the projectile for a distance of several hundred yards can be

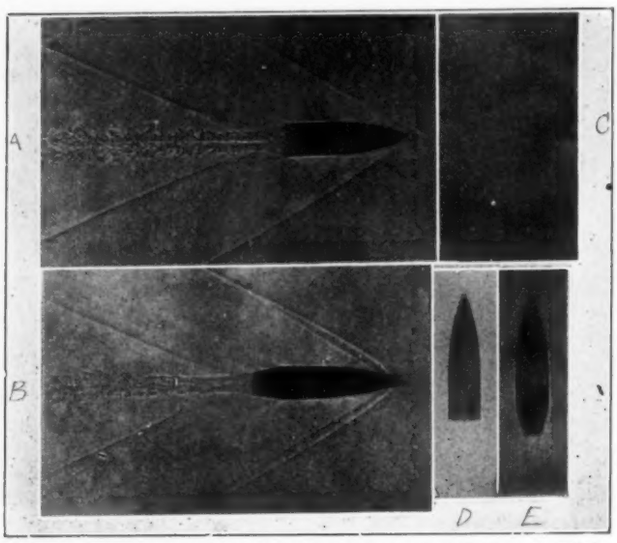


Fig. 6. Photographs of Flat-based and Boat-tailed Bullets in Flight
A. Flat-based Bullet at 2,600 f.s. B. Boat-tailed Bullet at 2,600 f.s. C. Flat-based Bullet at 1,152 f.s. D. Flat-based Bullet at 912 f.s. E. Boat-tailed Bullet at 960 f.s.

accurately determined, and it has been found that this course in general is a spiral path around the mean trajectory. In addition, velocity screens are placed at various distances which permit the measurement of the velocity at these points. From these velocity measurements the retardation can be determined.

Another set of tests is the so-called wind tunnel tests which consist of placing projectiles in air currents of various velocities with means provided for measuring the resistance. These air streams are provided by large air-compressors which are being manufactured for commercial purposes and which are being erected for shop tests prior to being shipped to their destination. The ballistic tests in question are made during shop tests on these machines. It may be stated that the machines are of enormous size, the larger ones capable of delivering 60,000 cubic feet of air per minute with pressure limits varying from a few pounds up to 30 pounds per square inch. By the use of suitable nozzles, it has been found practicable to maintain air streams one foot in diameter having a velocity of 1,500 feet per second. The power required for the production of these streams is 5,000 kw.

Work is proceeding steadily on both the firing and wind tunnel tests, but progress on investigative problems of this character always appears somewhat slow since it is necessary to analyze carefully the results of each test before proceeding with the next. Considerable work has been done in the wind tunnel tests to determine shapes which give the least resistance to air streams, with the projectile placed so that its axis is parallel to the direction of the stream and also at slight angles to the stream, the latter to simulate the condition when the axis of the projectile does not coincide with the trajectory. It is not practicable to obtain air currents of velocities approaching those of high-power gun projectiles or even the outer zone velocities of the new howitzers, but velocities have been obtained slightly above the velocity of sound, above which point it is believed that the law of resistance does not greatly change.

The outstanding feature of these tests thus far is that the shape of the point is important for high velocities. We are now using lengths of point corresponding to 9 or 10 calibers radius of ogive and further increase might be used with beneficial results, except that there are practical limits of the overall lengths of projectiles which are convenient to use, and the point will presumably be reached where decreased resistance, due to further lengthening of the point, would be more than offset by the increased resistance due to increased instability in flight. The shape of the base is more important for lower velocities than for higher velocities. While it has been impracticable in the wind tunnel to carry the tests to the limit where boat-tailing ceases to have effect, the results so far obtained indicate that this limit is reached in the muzzle velocity of some of our high-powered guns. Of course, the velocity of the projectile over the latter part of the trajectory falls off so that there will undoubtedly always be some beneficial effect of boat-tailing.

The reason for the large effect of the base design on low-powered guns and the smaller effect on high-powered guns is that the head-on resistance increases so tremendously with increased velocity. This results in the tail drag produced by the rear vacuum being a considerable percentage of the total force in the low-powered guns and a rather small percentage in high-powered guns. The shapes of projectiles and bombs, the latter having a comparatively blunt nose with long tail and the former a sharp point and either square base or one slightly boat-tailed, are perfectly logical designs for their respective velocities.

Interesting results were obtained in the wind tunnel with reference to the effect of the location of the rotating band. A rotating band placed at the rear edge of the square base projectile increased the resistance of the air about 10 per cent, although the diameter was increased less than 2 per cent. With the band moved away from the base a distance of from ¼ to ½ of the projectile diameter there was no increase in resistance between a projectile without rotating band and one with the band so placed. Similarly, the rotating band placed just at the edge of the boat-tailing increases the resistance from 25 per cent to 30 per cent. When moved away from this position the increased resistance was materially less. Two bands placed on a projectile, one at the point where the head merges into the bourrelet and the other at the extreme edge of the boat-tailing, increased the resistance as much as 100 per cent over the same projectile without rotating band. These results indicate the great importance which must be attached to the question of location of rotating band or any similar projection on a projectile. Bands located so as to produce increased resistance are also found to produce inaccuracy.

Another important point determined by the wind tunnel tests is the increased resistance due to the axis of the projectile making an angle with the direction of the air current. The resistance with this angle equal to 15 degrees was in some cases as much as two and one-half times that of the same projectile with the axis parallel to the

current. This indicates the tremendous importance of having a projectile that will travel with its axis as closely coincident with the trajectory at all times as practicable because the increased resistance for only a short time will greatly decrease the range, whereas any variation from round to round in the time of this increased resistance would greatly affect the accuracy. It is impracticable to elaborate on these tests here. The results obtained are interesting and are considered extremely important.

Ammunition for Divisional Artillery

The Caliber Board specifies that the weight of the projectile for the divisional gun be not over 20 pounds. It is possible that the Board had in mind a caliber of about 3.3 inches when suggesting this weight. It was found that this caliber could not be provided within the weight limit so that the 75-millimeter caliber was adopted after study and discussion with the Field Artillery representatives on the Ordnance Committee. In agreeing to this caliber, the Artillery members desired that the heaviest projectile practicable be furnished, preferably weighing not under 15 pounds. This is the same weight previously used in the 3-inch field gun, a somewhat larger caliber than the 75-millimeter. Moreover, the 3-inch projectile was of the blunt point type with bursting charge of only about 5 per cent, whereas the new 75-millimeter shell which has the long hollow point has been given about 10 per cent of bursting charge to meet requirements laid down. The explosive material weighs only about one-fifth as much per cubic inch as metal. Therefore, the combination of small caliber, long hollow point and increased capacity has resulted in a projectile which is rather too long for stability with the regular 1 in 25 twist. It does give fairly good accuracy with a twist of 1 turn in 20 calibers. This increase in twist, of course, places more stress on the rotating band, and therefore will undoubtedly result in failure of the band at an earlier stage. Failure of the band means the limit of the accuracy life of the piece. Taking everything into consideration, it is by no means certain that the 13½-pound weight adopted by the French during the latter stages of the war, our Mark IV type, would not be a better compromise than the 15-pounder.

The Caliber Board prescribes that the projectile shall be an effective man-killing type, which presumably means that it shall be an effective fragmentation type, and that it should be designed to give maximum ballistic effect and have the largest bursting charge consistent with this effect. There are no definite data available as to the relative merits of fragments and shock effect, nor is definite information available as to the size of bursting charge which gives the best fragmentation effect considering not only the size but the velocity and distribution effect. Designs laid down have therefore been somewhat of a compromise, containing a relatively large bursting charge, namely, about 10 per cent. This is about the percentage used by both the French and the Germans in their latest designs of field gun shell, the Germans having increased the percentage from somewhere around 3 per cent to 5 per cent and the French having reduced from about 14 per cent. This size of bursting charge gives good fragmentation effect and at the same time good noise and shock effect and is probably about as good a compromise between the two as can be reached.

No great difficulty has been encountered in meeting the requirements for range of the divisional gun, namely—15,000 yards. Part of this increase has been met by improvements in the ballistic qualities of the projectile and part by increased power of the gun. It is interesting to note that there has been more increase in range due to improvement in the projectile than due to increased power of the gun. For example, the existing 75-mm. field gun firing the latest improved shell will give a range slightly over 13,000 yards, whereas the new gun with increased power, firing the old type projectile, will give a range of only about 11,500 yards. The present service 75-mm. gun with old type projectile gives a range of only about 30

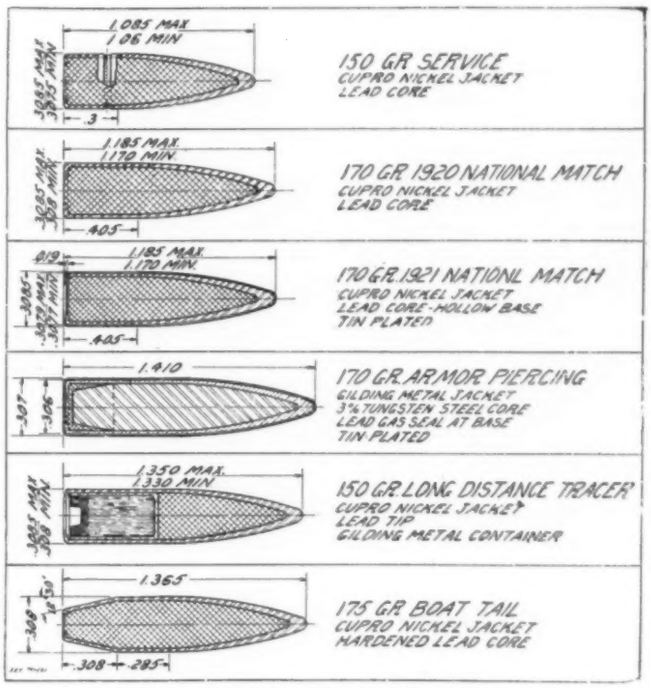


Fig. 7. Types of Small Arms Ammunition

per cent of the theoretical range *in vacuo*. The new gun with latest type projectile gives practically the same percentage. The increased resistance due to higher velocity has counteracted the improvement made in ballistic shape. The increased length of the new projectile itself and also the increased length of the round are of interest. There was considerable discussion in the Ordnance Committee on the length of the round, it being felt that it was too long for convenient handling, in addition to being bulky in transportation. At present there appears to be some prospect that either a reduction in chamber capacity or a reduction in the length of the gun can be made. It will be necessary to determine which will result in the greater advantage. The question as to whether there can be a reduction and how much is somewhat unsettled by the fact that flashless powders may require a larger chamber than the present service powders, depending upon the composition finally selected. In connection with the improvement of ballistic qualities in projectiles, it might be stated that as early as 1908 a projectile was tested for the 3-inch field gun having ballistic qualities nearly as good as the latest war-type for the 75-mm., namely, the Mark IV. At that time, however, there appeared to be no particular call for increased range. Carriages were only being used up to about 15 degrees of elevation and considerable increase in range was still possible without changing the design of shell. Moreover, at that time shrapnel was considered the most important ammunition for the field gun and it was impracticable to make the shrapnel to the new

contour on account of the fuze. The question of improved ballistics in so far as mobile artillery guns were concerned was, therefore, more or less abandoned until there was real demand for increased range. Some work was done in the meantime on improving the ballistic qualities of seacoast projectiles but that was from the standpoint of obtaining increased striking velocity that would result in increased armor penetration rather than from the standpoint of obtaining increased range.

With respect to improved time fuzes, work is being carried out mainly to meet antiaircraft requirements. Two lines of development are being followed: one, the mechanical type which is being developed by clock-makers; the other, the powder-train type. Effort is being made to improve the time-train powder, to obtain better waterproofing, and to control the burning so as not to be affected by barometric conditions. The solution of the problem for antiaircraft purposes will permit using either the same fuze or the same principles for a fuze to meet mobile artillery requirements. It may be stated that there appears to be no prospect of having sufficient production facilities to meet requirements for both antiaircraft and field artillery in a mechanical-type fuze. As far as can be seen at the present time, the powder-train type must be utilized for the greater percentage of requirements.

On the question of shrapnel, there are no particularly new developments. It was found impracticable to give shrapnel the same ballistics as the now stream line shell. In the first place, a shrapnel filled with service material would be much shorter for the same weight than the high explosive material. It is difficult to give any great boat-tailing to the shrapnel due to the thinness of the shrapnel case which does not permit moving the band forward to the same extent as on the shell. Furthermore, there are difficulties in placing a time fuze under a false ogive due to the impracticability of obtaining rapid setting. Efforts to change the contour of the fuze itself have not been successful up to the present time because change in the contour produces great change in the pressure around the vents and this in turn affects the burning of the time-train This question can probably be solved in time, but even with its solution the ballistics of the shrapnel end of the shell cannot be made identical. As the shrapnel is not considered effective for long ranges, at least with the fuze now available, development of a stream line type is not considered essential.

One difficulty encountered in connection with the use of shrapnel in both the 75-mm. gun and the 105-mm. howitzer is that the carriages are not designed to be stable at low elevations with the super-charge. The effectiveness of the shrapnel is dependent upon high ball velocity which requires high initial velocity. It is also generally used at the lower elevations mainly in direct fire. The best that can be done, therefore, is to adopt as high a muzzle velocity for the shrapnel as is compatible with reasonable stability for the gun, and use the regular zone charges for the howitzers. Under these conditions, it is somewhat doubtful whether the shrapnel will be sufficiently effective with the howitzer to warrant its adoption. It was decided after consultation with the Field Artillery representatives on the Ordnance Committee, that the development should be completed, leaving the decision as to its use for later consideration.

Ammunition for Larger Calibers

The Caliber Board requirements for ammunition for artillery of greater power than the divisional artillery are very similar to those for the latter, except that separate loading is prescribed or permitted for all weapons except antiaircraft guns, and the howitzer shell are required to be designed for the maximum bursting charges consistent with satisfactory ballistic qualities.

With respect to the weight of shell for the corps gun, the Field Artillery representatives on the Ordnance Committee desired to adhere as closely as possible to the maximum of 60 pounds permitted by the Caliber Board, but with a caliber of 4.7 inches a shell of this weight is too long for stability in flight and it was necessary to limit the weight of both shell and shrapnel to 50 pounds. Ninety-five pounds was selected for the weight of shell for the corps howitzer and, as required by the Caliber Board, this shell is identical with that selected for the Army gun. The use of the same shell in the corps howitzer and Army gun requires that the howitzer band be wider than really needed and entails a slight sacrifice in bursting charge effect for the howitzer, but these disadvantages are relatively unimportant compared with the resulting expedition of production and simplification of supply. A weight of 200 pounds was selected for the 8-inch Army howitzer shell which is to be identical with the shell for the 8-inch gun on a field mount.

For the 4.7-inch antiaircraft gun with muzzle velocity of 2,600 f.s., the projectile weight adopted is 45 pounds. Some consideration has been given to the question of using projectiles lighter than 15 pounds for the 3-inch antiaircraft gun with higher velocity. This would reduce the time of flight and permit a slower twist, thus reducing the rotational velocity of the projectile and the difficulty of producing a satisfactory fuze of the mechanical type. The proposed reduction in twist for the 3-inch would make the rotational velocity about the same as for the 4.7-inch caliber, thus more or less equalizing the mechanical fuze problem.

Some preliminary work has been done on the question of effectiveness of projectiles against airplanes. It is concluded that a projectile of 3-inch caliber produces practically no shock effect on the plane, so that the Caliber Board requirement, which calls for shell of maximum bursting charge rather than maximum fragmentation effect, should apparently be modified. The moral effect is very questionable because the aviator probably does not hear the bursts due to noise from the motor.

Ammunition for Infantry Weapons

For the new 37-millimeter infantry gun under development there will be provided a base-fuzed armor-piercing shell to pierce 1-inch armor at 500 yards with normal impact, a high explosive shell and canister. The infantry mortar will be provided with shell similar to that for the divisional gun, with probably the same fuzing. The ammunition for the 6-pounder tank gun will be a base-fuzed armor-piercing projectile for use against protected machine-gun nests, etc., as well as against enemy tanks, and canister for use in the open.

A number of tests have recently been carried out against an obsolete tank. From these it appears that almost any direct hit from an artillery shell, 6-pounder and above, will probably disable a tank, as also will a hit with small fragmentation bombs. In these firings, service 75-millimeter shell, point-fuzed type were used. When firing the shell with fuzes the burst was usually outside; when firing shell without fuzes penetration was usually obtained, the shell exploding due to shock effect, but with delayed action sufficient to burst the projectile inside the tank. Projectiles and bombs which did not actually hit the tank generally produced little effect.

Measuring the Life of a Gun

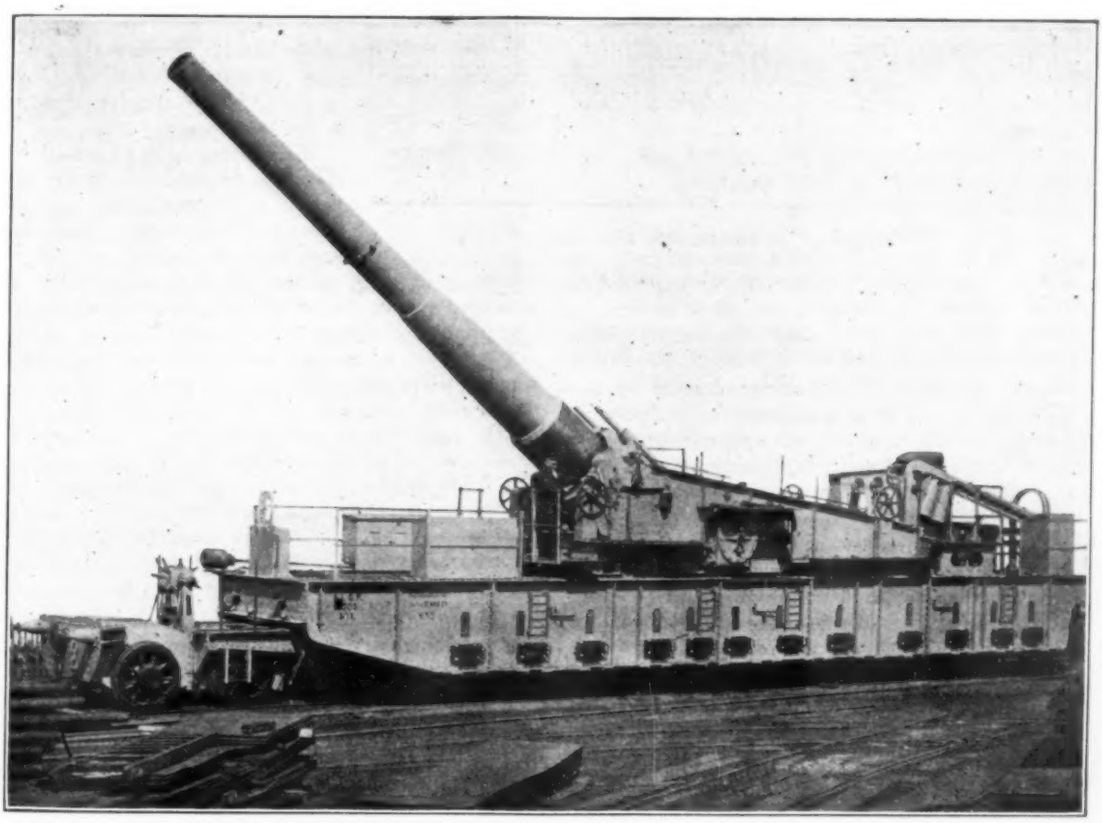
By

PHILIP SCHWARTZ

WHAT is meant by the life of a gun? The first guns ever used were considered to be in good condition as long as they functioned, and often a gun's life would not be thought ended until it had exploded and perhaps killed or wounded its crew. This was at a time when accuracy of fire was of little importance, and when the noise of the shot accomplished as much as the projectile itself. At present, an artilleryman would say that the life of a gun is ended when the dispersion of its shots from round to round becomes so great compared with the dispersion of the shots of a new gun, that the effect of any group of shots is not worth the cost, measuring the cost in men, money, and time. Life and accuracy life are the same when applied to a gun.

With this definition as a starting point it is possible to attempt to solve the following problem: Given a gun, used for some time and subjected to various kinds of treatment and weather, from which an unknown number of rounds has been fired, to decide by experiment whether or not the gun's life is ended, that is, whether it needs relining. The question of the condition of the carriage should not be confused with this one, for the projectile is out of the bore of the gun before the carriage has received any appreciable motion.

Visual inspection of the gun, star-gauge measurements, and impressions of the bore, seldom decide definitely anything connected with this question, unless, of course, the gun has a glaring defect. Measurement of velocity when using service powder charge and projectile, tells how much is the loss in velocity due to erosion and consequently the loss in range due to this loss in velocity, but it tells nothing about dispersion in range from round to round. Incidentally, this loss in velocity due to erosion is of little importance, for the loss in range caused by it is never very large, ordinarily not greater than 5 per cent. Although this loss is appreciable, it seldom causes anything approaching the trouble connected with relining a gun.



How Many Rounds will this 12-inch Gun, Railway Mount, Model 1918, Fire with Accuracy?

Sometimes it is possible to fire a few projectiles through jump cards and then examine the holes. It may also be possible to fire a few projectiles into a recovery field, and make an examination of the rotating band. However, neither of these experiments give sufficient information to settle the problem. They can only give qualitative results

The only logical method of determining how a gun has aged, is to compare by actual experiment, the accuracy results obtained by firing from a new gun with those obtained by firing from the old one. It is necessary to fire both guns at the same time and under identical conditions with regard to line of fire, type of ammunition, gun crew, range observers, etc., in order to avoid errors of the day or personnel errors. To avoid errors of the moment such as those due to variation in wind value and direction from moment to moment, *the guns shou'd be fired alternately,* that is, a round from one gun and then a round from the other, and so on throughout the firing.

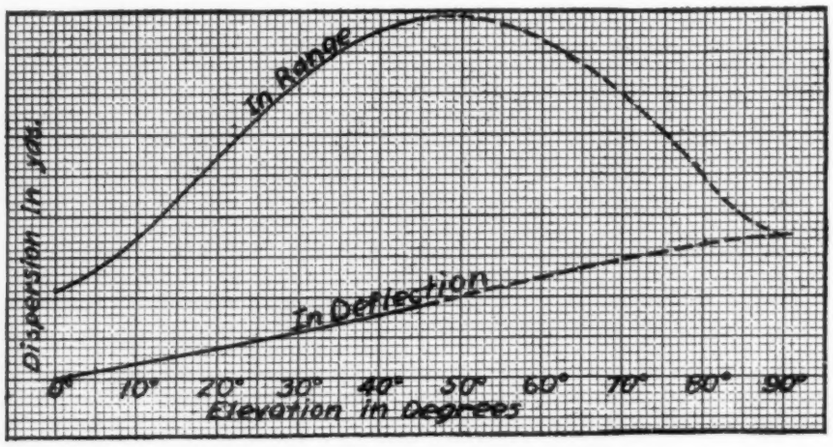


Fig. 2. Variation of Dispersion with Elevation

The elevation at which the firing is made is of the greatest importance, and it is the principal purpose of this paper to discuss this question. As an illustration of what is meant, the case of the 6-inch gun serves admirably. Before the past war this gun was considered to be one of the most accurate that the United States service possessed. This was in the period when little firing was done above 15° elevation. During the war it was decided to raise the maximum elevation of the gun and to obtain more of its ranging power. Upon firing at 40° elevation it was found that the dispersion of the shots was tremendous, sometimes being as much as 30 per cent of the range. It was later discovered that this large dispersion was due to a poorly designed rotating band which showed its imperfections most clearly only when the air was allowed to act on it for a sufficient length of time, as occurs in the case of a high angle trajectory. Similarly, it is true that a projectile which has too little or too much rotational velocity to give it stability in flight will plainly exhibit this error in design only when fired at higher elevations.

At small elevations—a few degrees—the air trajectory is only slightly different from vacuum trajectory. For a vacuum trajectory the range is a function only of the initial velocity and elevation, and is not affected by the weight or shape of the projectile. At higher elevations the air trajectory is very different from the vacuum trajectory, the range at 45° in air averaging for all United States guns in the neighborhood of a third of that in vacuum for the same initial velocity and elevation. It can, therefore, be seen that changes in the mechanical properties such as stability, or changes in the exterior shape of the projectile such as a poorly engraved rotating band, are effected only at elevations where the actual trajectory is very different from the vacuum trajectory. For example, when firing at 1° elevation, it does not matter much whether a round ball or an elongated projectile is used, the range will be about the same for both. However, at 45°, the elongated projectile will range much farther than the spherical projectile.

Two United States range tables which have been consulted show the following values of the proving ground probable error in range. The range probable error is ordinarily always greater than the deflection probable error, and for this reason it is of greater importance as in the table below.

The above table shows that as the elevation is increased from small elevation to larger ones, the dispersion increases more rapidly than the range, and is most noticeable at higher elevations. Proving ground firing usually shows that the measured dispersion at low elevations seems to be caused principally by dispersion in jump and errors in setting of sights. That is, at small elevations, the design of the carriage and the errors of sighting account for a large part of the dispersion, and it is not caused by the bore's action on the projectile to any extent, whereas at such elevations as 45° the effect of the dispersion in jump and errors in setting is almost negligible. At small elevations an old gun gives about the same dispersion as a new one, provided they are both mounted on similar carriages. At higher elevations the carriage makes little difference, and the old gun invariably exhibits less accuracy than the new one.

The foregoing has attempted to show that unless accuracy firings are made at the proper elevation, little can be said from the results concerning the relative accuracy of the gun or projectile. *The most suitable elevation is in the neighborhood of* 45°. The life of a gun can then be measured by *actual comparison* if the precautions listed in this paper are followed, without fear of other factors confusing the result. Of course, before a definite answer to the question can be reached, the proper authorities must decide just how bad the dispersion of a gun may become before relining becomes advantageous for economic reasons. For example, it may be sufficient to inform the artilleryman that if the dispersion of the gun becomes three times the dispersion of a new gun, it is time for relining the old one; or any other suitable factor may be used after investigation of the matter. When sufficient data have been accumulated it may be possible to say that after a gun has been fired a given number of rounds, its accuracy is gone and it required relining or replacing

Gun.	Projectile.	Velocity.	Elevation.	Range. yards	P. E. in Range.	Vacuum Range
75-mm American	Mk. IV shell	1876 f. s.	1°	1100	28	1270
			10°	5750	50	12500
			45°	11100	117	36500
155-mm G. P. F.	Mk. III shell	1955 f. s.	2°58′	3300	13	4050
			10°	7600	38	13500
			35°30′	15000	140	37300

Industrial Mobilization

THE national defense act, as amended June 4, 1920, establishes the broad outlines of a military policy for the United States. Under the provisions of this law the Army of the United States, consisting of the Regular Army, the National Guard, and the Organized Reserves, is at present organized, trained, administered, and supplied. Congress, in amending the national defense act, made a fundamental change in the business organization of the War Department. The Assistant Secretary of War, under the supervision of the Secretary, is now charged with the control of policies affecting the business administration of the Army.

The duties of the Assistant Secretary of War are defined in section 5a of the national defense act. As prescribed therein he has two distinct functions: First, he is responsible for supervising the procurement of all military supplies by the War Department and other duties relating thereto; second, he is required to see that adequate provision is made for the mobilization of matériel and industrial organizations. The statute says he shall be charged with "the assurance of adequate provisions" for industrial mobilization, but this must be taken to mean that he is responsible that adequate plans are made.

Wars are no longer fought by the armed forces alone. Every man, woman, and child, every resource and every dollar in the entire Nation must throw its weight toward victory in time of war. Industry alone can not win a war; but it can lose a war by failing to supply the armies with munitions, vital to their fighting efficiency.

In planning for procurement of supplies in time of war, it is, of course, necessary to know what kind of supplies will be required, and how much will be needed. The General Staff indicates to the Secretary of War the military program which is believed adequate for any emergency and determines the types of equipment and tables of allowances. All questions affecting the procurement of supplies—that is, where they can be procured, who will procure them, the rate of production, and maintenance of an economical program—are determined under policies laid down by the Assistant Secretary of War, the business head of the War Department. The cost of the supply program must be estimated in order that Congress may know the extent of appropriations required and the Treasury Department may have the necessary data upon which to make plans for financing the war.

In this connection the War Department is giving most careful attention to the ways and means whereby profiteering may be controlled in time of war. The principle that the men at home shall not profit from war while their fellows are staking their lives and their health for their country, is fundamental as a proposition of common justice. Such a policy was affirmed in a nation-wide referendum by the Chamber of Commerce of the United States during the World War and was repeatedly commended as a principle of government by President Harding. It may, therefore, be regarded as a fixed national policy for the future.

An army requires hundreds of thousands of items of supply, many of which are a special design not produced commercially in time of peace. Before the War Department could approach industry in order to discuss production, it was first necessary to standardize specifications for supplies wherever practicable. This has been done by adopting, as far as possible, commercial standards, thereby insuring quicker production and reduced costs. At the same time, it has reduced the large number of contract forms, previously in use, to one single form which is about to be adopted for all war contracts. The adoption of such a simple form should obviate many of the mistakes made in the World War by inexperienced buyers for the Government.

Plans for procurement do not stop with the determination of the finished article, but the War Department must go further and plan for the procurement of machines for the making of its matériel, for securing the necessary raw materials which might become critical in time of war, and for insuring an adequate supply of labor, of power, and of transportation facilities.

This phase of procurement planning goes beyond the strictly military features and merges into the broader field, which for want of a better term has been called "industrial mobilization." By this term we mean the conversion of the industrial effort of the Nation from peace production to war production in an orderly manner, so that supplies can be furnished promptly, economic losses minimized, and the return to normal economic conditions at the conclusion of the war facilitated.

In order that these plans may be complete, it is necessary that the war requirements of the Navy, shipping, the railroads, and of the civilian needs, be considered. Cooperation with the Navy will be accomplished by the recently created Army and Navy Munitions Board. It will be necessary, in time of war, to create an agency similar to the War Industries Board to coordinate the civilian demands with those of the Army and Navy.

The following indicates the steps which are being taken

WAR DEPARTMENT,
Washington, June 28, 1923.

In the following pages an effort has been made to set forth briefly some of the salient features of the measures required in time of peace to insure the flow of munitions and supplies needed by our Army in the event of war.

Constructive suggestions are invited from all officers and civilians whose attention may be called to this matter. Requests for information may be addressed to any of the chiefs of the supply branches or their agents throughout the United States, or to the office of the Assistant Secretary of War.

DWIGHT F. DAVIS,
The Assistant Secretary of War.

in working out a plan for the procurement of supplies for the War Department in time of war:

> First. Having determined what will be required, it became necessary to figure out how much would be required. This necessarily depends upon the tables of allowances and the mobilization rate, which rate also determines when the supplies will be required.
>
> Second. Having worked out in detail the amount of supplies required, it then became necessary to determine where and how they could be procured. This has been done by the establishment of procurement districts by each branch of the War Department, to each of which has been apportioned a proper share of the total requirements. A table showing the location of district headquarters for each of the procurement branches is attached hereto. In order to prevent competition among procuring branches, facilities requested by them have been tentatively allocated for the purpose of procuring the supplies required. The officers in charge of procurement districts are engaged during the present year in making a survey of establishments required to meet the supply program.

There are seven supply branches in the Army. The Quartermaster Corps is responsible for the procurement of all subsistence and forage, all clothing, personal equipment, tentage and general equipage, fuel, oil, paints, vehicles, harness and saddlery, hardware, stoves, tools, furniture, mess equipment, cordage, construction materials, motor vehicles, marine equipment, repair machinery, laundry machinery, and all animals.

The Ordnance Department procures rifles, pistols, machine guns, artillery and ammunition of all kinds, aircraft bombs, fire-control instruments, target materials, grenades, trench-warfare materials, pyrotechnics, special motor vehicles, tanks, and tractors.

The Signal Corps procures communication equipment of all sorts, wire and cable, radio equipment, batteries, photographic and meteorological equipment, and pigeons.

The Corps of Engineers procures surveying equipment, lithographic and map-making materials, searchlights, bridges, railroad rolling stock, railroad shops, lumber for troops in the fields, and water-supply equipment.

The Air Service procures all airplanes and balloons, the engines therefor, special raw materials which are needed for its aircraft, such as spruce and air-plane dope. It also buys special trucks needed for its work, lubricants, aerial signaling apparatus, and special aircraft armament.

The Medical Department procures hospital supplies, surgical, dental, and veterinary instruments, drugs, chemicals, reagents and laboratory supplies, and all hospital equipment and furniture.

The Chemical Warfare Service procures war gases and their containers, chemicals, smokes, incendiary materials, gas masks, and other gas defense equipment.

Each branch has a distinct problem. We have those branches of which the Quartermaster Corps is the chief representative, dealing in vast quantities of supplies, mostly commercial in character. On the other hand, we have the case of the Ordnance and Air Service dealing in items which are either not produced commercially in time of peace or in such limited quantities as to have little effect upon war-time procurement. With the first class (those dealing in commercial products) the problem is merely one of stimulating production for which peace-time facilities already exist. The main thing in this connection is to see that specifications follow as closely as possible commercial standards.

The problems facing the Ordnance Department and Air Service are peculiarly critical. In the case of the Ordnance Department, the maintenance of war reserves is vital. While at the present moment we are fairly well off in this connection, 10 years or even 5 years hence we probably will be in much worse shape, especially in the matter of explosives. Weapons of war change rapidly, and it is very difficult to forecast 10 years in advance the types that will be required. It is very unlikely that Congress will ever consent to appropriate in time of peace sufficient money to maintain a war reserve which military men would like to have in order to insure a more rapid mobilization. There seems to be, therefore, but one thing to do in connection with the Ordnance problem, and that is to secure sufficient appropriations annually to keep the art of manufacture alive. This will involve placing annually "educational" or "experimental" orders with selected facilities, furnishing them with the necessary jigs, dies, gauges, etc., in order to encourage them to experiment in the manufacture of these noncommercial articles.

The Air Service problem is even more critical. It is wholly dependent upon an infant industry which offers considerable hope for the future, but which, at the present time, is in bad condition due to lack of interest in commercial aviation. Congress is considering proposals to encourage civilian aviation through some legislative stimulus of flying, as well as the encouragement of mail service by airplanes, it is hoped to encourage aircraft production so that it may furnish some foundation for expansion for war-time requirements.

The chiefs of the supply branches have assigned various officers of the Regular Army to the duty of making continuous studies of the problems of procurement and submitting professional papers on the subjects assigned. Several hundred officers are now making these studies in addition to their regular duties. Some reserve officers also have agreed to make similar studies.

The general idea is that for each class of supplies, of which there are about 10 in each branch, there will be a small group of Regular officers and a group of Reserve officers who are studying the question from various angles; this will give to each procuring service a number of officers who are well qualified to carry out the responsibilities of the service in procurement matters. In this manner Regular officers will learn something of industry; Reserve officers and others engaged in industry will become familiar with the military features involved and all working together will be able to prepare the necessary detailed plans and keep them up to date to meet any changes in probable war needs or industrial progress. As the planning develops, critical features will become known and deliberate decisions can be made, the advice and judgment of men of great experience in industry being obtained on questions of major importance.

The plans for expansion of personnel, in time of war, must go far beyond the personnel available in the Regular Army. By interesting Reserve officers and patriotic civilians in this work, keeping them informed of the scope of the plans and, in the case of Reserve officers, calling them to active duty occasionally, a reserve of industrial staff specialists corresponding to the military reserve will be created. In this way the work of furnishing the expanded Army in an emergency with supplies and munitions will proceed smoothly as the work will be directed by men trained in civil life.

(Continued on Page 116)

The Military Use of Commercial Explosives by the Germans

By

W. J. GERMAN

DURING the three months prior to the signing of the Armistice, the Germans found that due to the shortage of certain materials, they could not keep up with the demand of their Army for military explosives. On the other hand, they had an oversupply of chemicals

Fig. 1. 2½-lb. Charge of Nitroglycerin Emplaced and Damage Done to the Opposite Rail

that go to make up the commercial explosives, such as the nitroglycerin and nitrate of ammonia explosives, which are used ordinarily for mining and quarry work.

Fig. 2. Frog Destroyed by Retreating Germans

During this time it was apparent that defeat was their lot, and they made plans as to the method by which it should be carried out. First, they decided that the end of hostilities was to come before the Allied Armies would get into Germany. To accomplish this, their plans were to put forth all possible effort to make the path of the advancing Allied Armies as rough as possible. This was done by destroying or demolishing all railroad bridges, culverts, rail switches, frogs and road beds. The highways, bridges, and culverts were also destroyed, and large craters were blown in the paved highways at short distances apart.

The accompanying illustrations show how completely their plans were carried out.

Fig. 3. Destroyed Bridge at Remilly

Figure 1 shows a 2½-pound charge of nitroglycerin explosive done up in a paper carton in the shape of a brick.

Fig. 4. Yard Switches Destroyed by Retreating Germans

This charge is so placed that it will destroy the end of two rails. The result obtained is shown on the opposite rail. Thirty miles of rail were destroyed in this way in the Meuse Valley, between Verdun and Sedan.

Figure 2 shows the effectiveness of one of these 2½-pound bricks of nitroglycerin explosive on one of the main line frogs.

Figure 3 shows the result of exploding several hundred pounds of nitrate of ammonia explosives around the main

Fig. 5. Destroyed Bridge at Pont Mougis

support of a small bridge which crossed a stream going into the Meuse River.

Figure 4 shows the entrance to a railroad yard with twenty tracks. Note how effectively the commercial explosives worked in completely destroying all switch parts. The effect upon and hindrance to an advancing army can readily be seen.

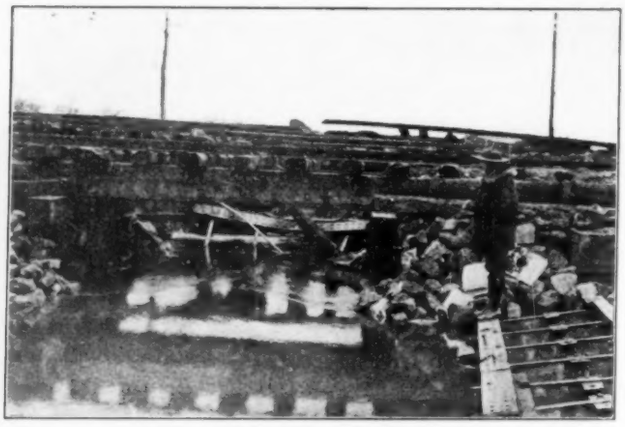


Fig. 6. Temporary Bridge at Mouzon

Figures 5, 6, and 7 show some of the temporary structures built by the engineers with improvised material. These pictures give the reader some conception of the delays to advancing troops, caused by the use of the commercial explosives.

Special attention is directed to the culvert shown in Fig. 7. Before the retreat of the Germans there was a 5 by 5 foot stone culvert under the double track. The Germans put several hundred pounds of explosives in this culvert and blew a crater 30 feet deep and 60 feet long. In order to make this fill quickly it was necessary to use the dynamite which the Germans left to blow down three stone buildings in order to obtain the required stone.

The destruction of the two ways of travel—railroad and highway—was so complete that the advancing American troops were greatly handicapped, and only soldiers on foot and light horse-drawn supply wagons could advance. Picture at this point an army of men going ahead on foot in

Fig. 7. Box Culvert Built by Engineers at Pont Mougis

almost continuous stream, taking with them all the fighting materials and foodstuffs that it was possible to carry and not knowing when it would be possible to get to them with additional supplies. Just imagine the truck trains of supplies held up at craters in the highways and others stuck in the mud in an effort to detour.

Most of this demolition work was done with nitroglycerin and nitrate of ammonia explosives. Large quantities of these explosives were left at several points by the retreating Germans, and about 2 per cent of their charges were misfired, so we had an opportunity to inspect their explosives very carefully and study their method of using them. One can readily see that they used them very effectively.

Thus, the importance of commercial explosives for certain military operations is apparent and the value of the industry to the national defense is obvious.

Industrial Mobilization

(*Continued from Page 114*)

It is hardly necessary to point out what a tremendous saving a sound plan for industrial mobilization will be in time of war. During the World War the Government departments competed with each other and there was much confusion and lack of coordination. Some industries found themselves swamped with orders they were unable to fill, while other industries were ruined by a sudden cessation of their normal business. In a well devised industrial mobilization scheme much of this can be avoided. This is a matter of vital importance to the taxpayers. The Army will be equipped for war months sooner than it was during the World War. The war will be shortened by just that much, thereby saving thousands of lives and billions of dollars. It will also mean a minimum dislocation of the normal economic effort and facilitate a return to peace conditions.

The Specific Heat and Thermal Diffusivities of Certain Explosives

Part I

By

A. M. PRENTISS

THE problem herein presented consists of a study of the specific heats and thermal diffusivities of certain explosives of commercial and military importance. The explosive materials selected for this investigation were supplied and the nature of the inquiry outlined by the Committee on Thermal Investigations, National Research Council, Washington, D. C.

In practice, the explosion of an explosive is generally effected by means of an initiating or priming substance, the nature of which is determined by the kind of explosive to be fired or the character of the explosion desired. These different conditions may be typified by (1) the so-called "propellant" powders, such as gunpowder and smokeless powder, which are fired by ignition, undergo combustion, and are used as propellant charges, and (2) the "high explosives," such as TNT. and nitroglycerin, which are fired by detonation, undergo detonation, and are used as disrupting and demolishing agents. In all cases the explosions are initiated by heat derived from flame or incandescent masses. In blasting, the blasting powder is fired by a train of powder in a running fuze or an igniter. In ammunition, the propellant is fired by the blast from a percussion or friction primer. In mines, torpedoes, demolitions, and in the general use of disruptive agents the explosives are fired by plain detonators, or by electric detonators. In plain detonators the explosion of the fulminate charge is initiated by ignited running fuse, and in electric detonators, the explosion is initiated by ignited cellulose nitrates or loose fulminate in which an "ignition-bridge" is imbedded.

It seems probable that in order to produce ignition and explosion of a substance by heat, the substance must first be heated to a certain temperature. Numerous experiments have established the fact that this temperature differs in general with the substance heated, but that it is a constant for a definite substance in a definite condition, and under definite experimental circumstances.

The "point of ignition" may be defined as that temperature at which a substance takes fire and continues to burn in the presence of a supporter of combustion. As explosives are either autocombustible or endothermous, the "explosion point" or "firing point" of an explosive may be the same temperature as its "point of ignition," or these temperatures may be different, especially in the case of substances which are "autocatalytic."

The "points of ignition" or "explosion points" have, as a rule, been determined by immersing the sample in a container in a bath and raising the temperature of the bath at a definite rate until explosion occurs, the temperature of a thermometer immersed in the bath being read at the time. The methods which have been followed are described by Brunswig,[1] Marshall,[2] and Snelling and Storm.[3]

For practical, as well as scientific, purposes we are concerned not only with the actual temperature at which a substance will explode, but also with the readiness and certainty with which this temperature is attained and propagated within the explosive. Thus, it is possible to conceive of two different substances, each having the same "point of ignition" or "explosion point," attaining this temperature at different rates when started from the same low temperature and exposed to the same source of heat and energy. It is evident this may be the case if the substances differ in their heat capacities or thermal diffusivities. For this reason the accurate determination of these physical characteristics become of primary importance.

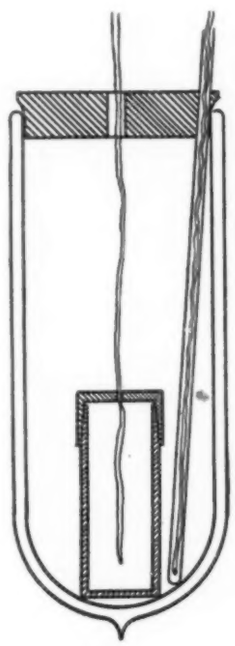


Fig 1

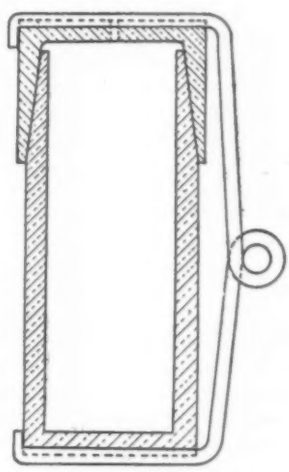


Fig 2

Although the importance of such data has been long recognized, it is remarkable that little or no attention has been devoted to the determination of the specific heats and thermal diffusivities of even our most important explosives. Thus a search of the literature especially devoted to explosives discloses a record for but two determinations—the

1 "Explosives," by H. Brunswig. (Translated by Charles H. Munroe and A L. Kibler), pages 56 et seq., N. Y., 1912.
2 "Explosives," by Arthur Marshall. (Vol. 2, pages 434 et seq., Phila., 1917.)
3 "The Behavior of Nitroglycerin when Heated," by W. O. Snelling and C. G. Storm. (Technical Paper 12, Bureau of Mines, 1912.)

specific heats of mono-nitrobenzene and the mono-nitro-napthalene.[1] No other records have thus far been found.

The function of specific heat in explosive phenomena is indicated by the following examples:

Alan Leighton[2] states that aluminum dust ignites at a lower temperature than 200-mesh standard Pittsburgh coal dust, but that, on account of the high specific heat of the aluminum it requires more heat for its ignition than the Pittsburgh coal dust does. Also Major Crozier,[3] in reporting his investigation of an accidental explosion of picric acid, says that "sparks from a carborumdum wheel, giving a continuous stream of brilliant sparks, instantly ignited gunpowder and dry guncotton, but failed to ignite picric acid either in the ordinary crystalline form or when in fine powder."

In practice it frequently arises that we have available for initiating an explosion only a very small source of energy and are therefore forced to seek a very sensitive agent. Today our only guide in this very important matter of the selection of a suitable initiating agent is the "explosion point." It would greatly facilitate matters, especially in a critical emergency such as the World War, if we had also on record the specific heat and thermal diffusivities of a considerable number of explosives. It would decrease the hazard of manufacture, storage, transportation and use of our commercial and military explosives if we could, through a knowledge of these characteristics, select among the initiating agents at hand that one having the highest explosion point which can be fired by the energy at command. Moreover, such data would enable us to secure for each type and kind of explosive the least sensitive initiating agent that will, with certainty, effect the explosion of the substance. In addition to these practical considerations this investigation also offers considerable interest from the theoretical point of view, as the accumulation of such data will in time permit of generalization. The whole question of the relation of diffusivity to density of loading offers an opportunity for the possible formulation of definite mathematical laws. Finally, when correlation between specific heats and diffusivities on the one hand and ignition temperature on the other are secured in a quantitative manner, it will go far toward increasing our knowledge of explosive phenomena and perhaps enable us to reduce the present-day hazard in the use of explosives.

Substances

The substances selected for this investigation were:

TNT. (2:4:6), (Trinitrotoluene), TNX. (1:3) (2:4:6) (Trinitroxylene), Tetryl (Trinitro-phenyl-methyl-nitramine).

The samples were furnished by the National Research Council and were obtained through the courtesy of the Bureau of Mines from its Pittsburgh Laboratory. These samples were purified by Mr. C. A. Taylor, Explosives Chemist, and Mr. Rinkenbach, of the Bureau of Mines Experiment Station. Mr. Taylor kindly furnished the following chemical histories of the samples:

Trinitrotoluene

The batch of TNT. purified was Grade I commercial trinitrotoluene which has been accepted by the War Department[4] and so was already in a rather pure state. The weight of the trinitrotoluene taken for purification was about five pounds.

The first step was the solution of the TNT. in about ten pounds of C. P. benzene, a mobile unsaturated solution resulting. In order to remove any insoluble matter present, this solution was filtered through paper, the filtrate being caught in a large evaporating dish. This was allowed to stand and cool over night at about 10° C., a heavy deposit of TNT. being obtained. The crystalline mass was drained, broken up, and air-dried for several days in order to remove mechanically held benzene.

The hard, dense material was then dissolved in boiling alcohol (95 per cent), the solution so obtained being filtered and allowed to cool to about 20° C. The dilute, reddish-brown solution was carefully drained from the mass of crystals deposited during this cooling, and the crystals were subjected to further purification. These crystals were needles of a light-yellow color.

They were dissolved in boiling 95 per cent alcohol to form a saturated solution, and this solution was poured into from two to three times its volume of distilled water having a temperature in the neighborhood of 20° C. A flocculent precipitate appeared immediately, and after stirring, the liquid-solid mixture was placed in a dark place for twelve hours in order to permit complete crystallization to take place.

The crystals were then caught on a Buchner filter, pressed as nearly dry as possible, washed five times with small portions of distilled water, and finally with several small portions of 95 per cent alcohol to facilitate drying. They were then spread on filter paper in a dark closet and allowed to air-dry, the material being turned over every day for a week. At the end of this time the material was weighed, transferred to sulfuric acid desiccators, and stored in a dark place.

The final product was a pure white, fluffy mass of very small needles which did not develop any coloration on being kept in storage in a dark place for some time. A total weight of 1,995 grams of the material was obtained, representing a yield of about 88 per cent. A determination showed it to have the following constants:

Setting point	80.1° C.
Melting point	80.0° C.

These determinations were made in the apparatus described in the paper on the TNT.—Tetryl system published in the *Jour. Industrial and Engineering Chemistry,* vol. 15 (1923), p. 73.

(1:3) (2:4:6) Trinitroxylene

A good commercial grade of this substance manufactured by E. I. du Pont de Nemours & Co. was purified in the following way:

The material was dissolved in hot benzene to form a nearly saturated solution and filtered while hot in order to remove any insoluble matter present. The filtrate was allowed to cool to 10° C. and the crystals deposited were separated and air-dried in order to remove mechanically held benzene.

The solid so obtained was crushed to a powder and mixed with acetone at ordinary temperature. The liquid-solid mixture was then heated to 50° C. with stirring and allowed to cool to 20° C., after which it was filtered. The solid residue caught on the filter was pressed and then air-dried.

The light-yellow crystals remaining after this treatment were dissolved in boiling chloroform, in which the substance is only fairly soluble, and crystallized from this solvent by allowing the solution to cool to 10° C. The crystals

1 Landolt-Bornstein-Meyerhoffer's Tables.
Smithsonian Physical Tables, 6th Revised Edition.
2 "The Inflammability of Aluminum Dust." (Technical Paper 152, Bureau of Mines, 1918.)
3 H. M. Inspectors of Explosives Report No. CCXXXI, March, 1918.
4 Military Explosives, War Department Document No. 947, Government Printing Office, 1919.

separated were caught on a filter, washed with cold chloroform, pressed between filter-paper, and air-dried in a dark closet. They were then placed in sulfuric acid desiccators for several weeks before being tested for melting and setting points.

The material resulting from the foregoing treatment was a finely crystalline mass of light yellow color which did not darken on standing in a dark place. Tests showed the following:

Melting point	181.8° C.
Setting point	181.5° C.

When making these determinations it was noticed that part of the material (a very little) sublimed and deposited in the upper part of the tube in the form of minute, pure white needles. The form of apparatus used for making these determinations was that used for TNT.

Tetryl

A good grade of commercial tetryl was purified by method similar to that used for the purification of TNT.

The tetryl was recrystallized from hot benzene after filtering to remove any insoluble matter. The crystals were air-dried to remove mechanically held benzene and then recrystallized from boiling 95 per cent alcohol.

The drained and air-dried crystallization product was redissolved in boiling 95 per cent alcohol and thrown out of solution by pouring into about twice its volume of distilled water. The mixture was allowed to stand in a dark place for several hours in order to cool and complete crystallization.

The crystals were caught on a Buchner funnel, washed several times with cold distilled water, and given a final rinsing with cold 95 per cent alcohol in order to facilitate air-drying. When this was completed, being done in a dark closet, the material was transferred to sulfuric acid desiccators and kept in a dark place for some time before use.

Efforts to obtain colorless tetryl proved unsuccessful. The material precipitated from hot alcohol by water appeared colorless, but as soon as it was filtered, a faint yellow color developed, even when the work was carried out in a dark room.

The final product of this purification was a mass of very light flaky crystals of a very faint yellow tint. The setting point was found to be 128.72° C, the apparatus used for this determination being the same as that used for the determination in the case of TNT.

This material was used in work done on the solubility of this substance [1] and on the system TNT—Tetryl,[2] as well as the analysis of mixtures of tetryl and TNT.[3]

Determination of Specific Heat

The specific heat measurements were carried out first because the specific heats are required in calculating the diffusivities and also because it was anticipated that after completion of the diffusivity experiments some of the materials would not be in suitable condition for the specific heat measurements.

In the determination of the specific heats of the materials studied the "Method of Mixtures" was used, and owing to the danger of decomposition, if not explosion, on heating these materials to the elevated temperatures ordinarily used in the method of mixtures, cooling instead of heating was employed in all cases.

[1] The Solubility of Trinitrophenylmethylnitramine (tetryl) in Organic Solvents. C. A. Taylor and Wm. H. Rinkenbach, J. Am. Chem. Soc., vol. 45 (1923), p. 104.

[2] Estimations of the Proportions of TNT and Tetryl from the Freezing Point Curve. C. A. Taylor and Wm. H. Rinkenbach, J. Ind. Eng. Chem., vol. 15 (1923), p. 73.

[3] The Analysis of TNT—Tetryl Mixtures. C. A. Taylor and Wm. H. Rinkenbach, J. Ind. Eng. Chem., vol. 15 (1923), p. 280.

Description of the Apparatus

The apparatus employed consisted essentially of a vacuum jacketed glass vessel, as a calorimeter, a metal capsule containing the explosive substance, a Dewar flask containing liquid air for cooling the capsule, thermo-couples for simultaneously measuring the temperatures of the explosive substance in the capsule, the water in the calorimeter, and the cooling medium; a vacuum jacketed ice bath for the fixed junctions of the thermo-couples; and a precision potentiometer, galvanometer and accessory apparatus for measuring the electric potential of the thermo-elements. The following is a brief description of the various pieces of the apparatus:

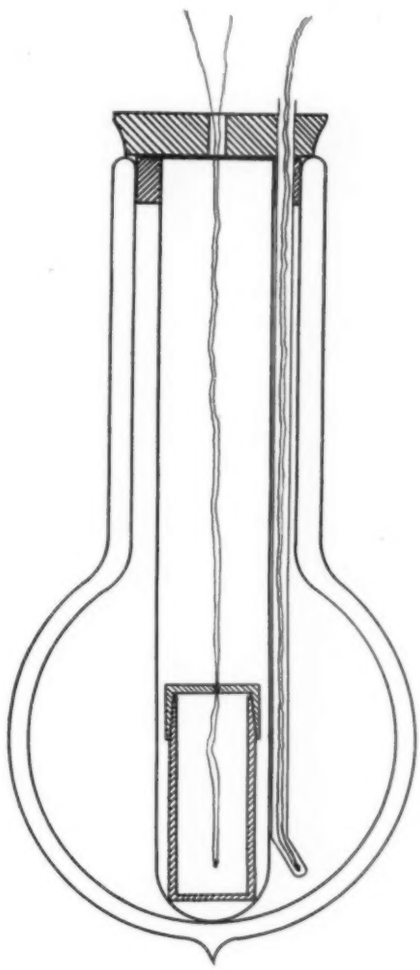


Fig. 3

The calorimeter consisted of a standard high-vacuum silvered glass Dewar vessel, of about 500 cubic centimeters capacity. This was closed by a tight-fitting cork through which were threaded the thermo-couple wires attached to the capsule. A small notch was cut in the cork cover to permit the entrance and free movement of the glass tube containing the thermo-element measuring the temperature of the water in the calorimeter. Fig. 1 shows the general arrangements of the calorimeter and contents. The rate of thermal change in the calorimeter during an experiment was found to be only about .001° per minute per degree difference in temperature, and as the calorimeter was always operated within 5° C. of room temperature, it was unnecessary to employ a surrounding bath.

The capsule holding the explosive substance was made of aluminum because of its high conductance and because it is not chemically attacked by the explosive materials studied. The capsule was about 2 c. m. in internal diameter, 6 c. m. long, and had a capacity of about 15 c. c. It was provided with radial vanes, made by folding a piece of very thin sheet aluminum, to accelerate the attainment of thermal equilibrium throughout the mass of material.

To close the capsule against the entrance of water from the calorimeter, screw threads are undesirable, since it is difficult to be assured that they are free from small particles of the explosive and the friction of screwing on such a cover might thus result in an explosion. The top of the capsule was therefore coned on the outside and provided with an accurately fitting conical cap. The coned surface could easily be thoroughly and carefully freed from the slightest trace of explosive material before closing. Arrangements were made to hold the cap in place by a stout wire spring, as shown in Fig. 2, the ends of the closed capsule being slightly grooved in order that the spring be not displaced by dropping. Afterwards, it was found that the use of the spring was unnecessary and objectionable, as the capsule could be securely closed by exerting sufficient pressure in seating the cap, and the presence of the spring made necessary a considerable enlargement of the cooling test tube immersed in the liquid air which not only materially slowed up the cooling operation, but also increased the evaporation of the liquid air. For these reasons, the spring was abandoned.

A *very slight* amount of heavy stop-cock grease was used to give greater insurance against leakage of water into the capsule and the greatest care exercised to avoid contaminating the explosive charge with this organic material, both in filling and in emptying the capsule. No difficulty was experienced in this direction.

The cooling apparatus consisted of a standard 1½ liter silvered Dewar flask with long narrow neck into which was inserted a test tube of just sufficient diameter to accommodate the capsule and of sufficient length to extend to the bottom of the flask. The test tube was held in place by a cork collar fitting loosely over the mouth of the flask and also holding the glass tube containing the thermo-couple for measuring the temperature of the cooling medium immediately surrounding the capsule. Fig. 3 shows the general arrangement of the cooling apparatus. The cooling flask contained its charge of liquid air from 48 to 72 hours, according to the number of capsules cooled.

A commercial thermos bottle served to maintain the ice bath into which the fixed junctions of all three thermo-couples were inserted in small glass tubes closed at one end and partly filled with kerosene. This very convenient method of maintaining the fixed junctions at 0° C. obviated the necessity of applying fixed junction corrections to the thermo-couple readings.

The thermo-couples were made of No. 30 double silk insulated constantan wire soldered to No. 36 double silk insulated copper wire. The copper wire of each circuit was cut about half way between its variable and fixed junctions and soldered to leads of No. 28 copper, which were run through suitable switches to the potentiometer. Special precautions were taken to prevent leakage of current in all circuits by protecting all joints with a coat of rubber cement and tape. To prevent confusion of circuits the various wires were identified at each end by attaching small pieces of worsted of distinctive colors.

The circuits measuring the temperatures of the cooling flask and the calorimeter were run to the potentiometer through a common multiple point pivot switch which permitted of quick and easy shift from one circuit to the other. In the case of the third circuit, measuring the temperature of the capsule, a different arrangement had to be made. As the temperature of the capsule varied from about — 190° to 20°, the direction of current reversed when the temperature passed through 0°. This made necessary a ready means for reversing the connections of this circuit to the potentiometer when the capsule was transferred from the cooling flask to the calorimeter. This was accomplished by a commercial double pole, double-throw copper knife switch mounted on a porcelain base within easy reach of the observer operating the potentiometer.

The potentiometer was a standard Wolff type having a resistance of 15,000 ohms and designed for 10,000 ohms per volt. Since this was used with two new Columbia dry cells in series giving a voltage of 2.9 volts, it was necessary to have a total of approximately 29,000 ohms in the circuit, or about 14,000 ohms in addition to the resistance of the potentiometer. This extra resistance, together with the necessary regulating resistance, was obtained by connecting in series with the potentiometer a Wolff ratio box of 10,000 ohms, and a variable Leeds & Northrup 4-dial resistance box, from which could be obtained anything from 1 to 10,000 ohms in 1-ohm steps.

The standard cell was a Weston cell, Model 4, the electromotive force of which had been carefully checked by the Bureau of Standards a few days prior to the beginning of the tests.

The galvanometer used was a Leeds & Northrup wall type instrument, having a resistance of 200 ohms and which gave a deflection of about 2 millimeters per microvolt. It was provided with a concave mirror of ½-inch diameter, having a focal length of 1½ meters. This was read by means of a reading telescope having a 33 millimeter objective and placed at a distance of about 2 meters from the galvanometer.

A standard mercury thermometer graduated from —2° C. to +102° C. in tenths of a degree was used to record room temperatures during the experiments.

Calibration

In temperature measurements by thermo-electric means accuracy and reliability of results are vitally dependent upon careful calibration of all apparatus used.

The potentiometer was first calibrated against the standard at the Bureau of Standards and all loose connections and leakage corrected.

The constantan wire for the thermo-couples was secured from the Geophysical Laboratory from the same spool used in compiling the table shown in the paper prepared by Mr. Leason H. Adams.[1] The method used for calibrating this wire and making the thermo-couple junctions is described by White.[2]

The three thermo-couples were calibrated at the following fixed points on the temperature scale:

+ 100.00° C.	(condensing steam)
+ 50.00 C.	(water bath with temperature measured by standard thermometer)
+ 25.00° C.	(water bath with temperature measured by standard thermometer)
0.00° C.	(melting ice)
— 182.98° C.	(Oxygen, boiling point)

[1] Printed in Bulletin 153, Sept., 1919, American Institute of Mining and Metallurgical Engineers.

[2] Thermo-element installations, Especially for Calorimetry, W. P. White, Jour. Amer. Chem. Soc., 1914, pp. 1856, et seq.

and the following results were accordingly obtained:

Temperature in ° C.	E. M. F. (Microvolts) Standard in Tablet	E. M. F. (Microvolts) Circuit No. 1 Calorimeter	E. M. F. (Microvolts) Circuit No. 2 Capsule	E. M. F. (Microvolts) Circuit No. 3 Cooling Flask
— 182.98°	5258	----	5260	5259
0.00°	0	0	0	0
+ 25.00°	991	991	988	990
+ 50.00°	2034	2031	2033	2034
+ 100.00°	4276	4274	4275	4278

In the case of the determination at 100° C. in condensing steam, a barometric correction was applied by taking the average of four readings and adding the E. M. F. (in microvolts) corresponding to the barometric reading, thus:

	Circuit No. 1 (Microvolts)	Circuit No. 2 (Microvolts)	Circuit No. 3 (Microvolts)	
	4259.3	4259.5	4262.3	Barometric reading gave steam temperature at time of reading of 99.70° C.
	4258.7	4264.5	4266.2	
	4261.5	4260.5	4262.3	
	4263.3	4265.0	4266.0	
				46 M. V. 1° C.
Average	4260.7	4262.4	4264.2	.30 C = 13.8 M. V.
Add	13.8	13.8	13.8	
	4274.5	4276.2	4278.0	

From deviation curves constructed for each circuit from the foregoing determinations and from the Geophysical Table referred to above, all temperatures recorded on the several thermo-elements were reduced to standard. After the installation of all circuits was completed the zero reading of the potentiometer was ascertained by disconnecting the batteries and short circuiting the potentiometer so as to cut out all exterior circuits except the galvanometer. When this was done no deflections were observed from readings upon any of the three lower scales which were the only ones employed in our experiments. The batteries were then connected up for several hours, the potentiometer balanced and short circuited so as to cut out all thermo-couple circuits, and it was found that the potentiometer then showed from 1 to 5 microvolts on short circuit, due to parasitic currents. As this was a variable quantity, arrangements were made to determine its value at the beginning of each series of temperature observations. This was most readily accomplished by providing a short circuit across the potentiometer terminals to which the thermo-couple circuits were attached. For convenience of manipulation this short circuit was run through a third point on the button pivot switch referred to above. This variable was compensated for by adjusting the normal on the galvanometer scale by whatever amount of lateral deflection was recorded at the time. This was checked at the beginning and end of each experiment and the normal on the scale adjusted accordingly.

At first a small drift was observed due to the effect on the dry cells of a change in room temperature. This drift was almost entirely eliminated by packing them in a straw box, with two inches of cotton surrounding the cells so as to insulate them from small changes in room temperature. When work was suspended for more than 24 hours, the dry cells were disconnected from the circuit to conserve their strength. Due to recuperation during a period of rest a slight drift was observed when the cells were first connected in circuit. This drift rapidly diminished and practically disappeared after the first 8 hours in circuit. By connecting up the dry cells about 8 hours before taking temperature readings, a very steady balance was obtained, and by frequently readjusting the normal on the deflection scale, errors due to drift were eliminated.

The potentiometer scales were graduated down to 10 microvolts and readings to tenths and interpolation to hundredths of a microvolt were obtained on the deflection scale by bracketing the normal index and interpolating by proportion.

Operating the potentiometer by the null method made the reading of more than two temperatures simultaneously at minute intervals impracticable with the accuracy demanded in our work, hence it was found more convenient to read the room temperature on a mercury thermometer than by using a thermo-couple with an additional circuit through the potentiometer. Accordingly, during all experiments the temperature of the surroundings was read on a mercury thermometer and observations were interpolated to hundredths by reading through a magnifying glass. As the temperature of the surroundings only entered the problem in a secondary way, accuracy beyond hundredths of a degree was unnecessary. The thermometer used to record room temperatures was checked at 0° (melting ice) and 100° (condensing steam) and found correct.

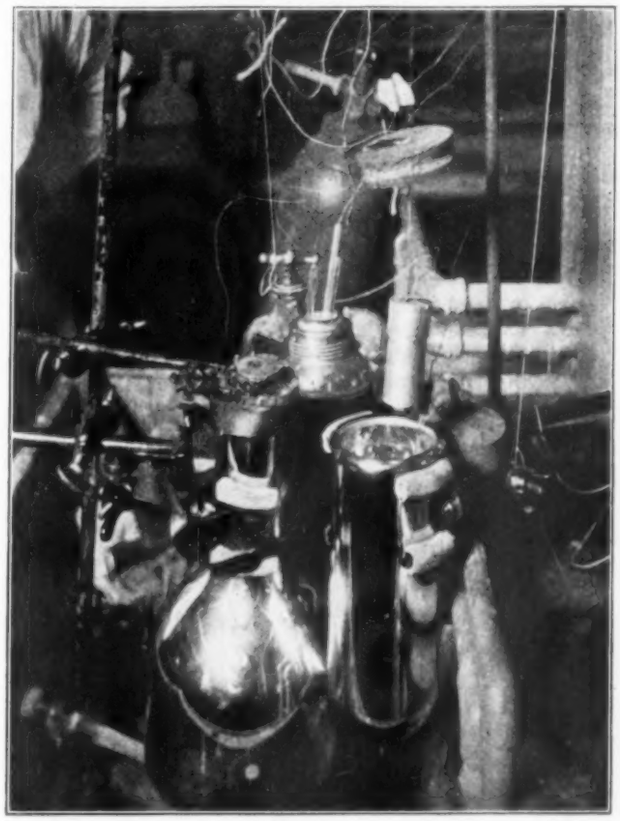


Fig 4

The final step in the calibration of the apparatus was the determination of the water equivalent of the calorimeter and contents. The only contents of the calorimeter was the glass thermo-couple tube which was also utilized as a stirrer. The calorimeter (see Fig. 1) was found to weigh 227.000 grams, the glass tube 3.860 grams, and the kerosene in the tube 0.140 grams. Caliper measurements and computations showed that the inner wall of the calorimeter constituted 40.8 per cent of its total mass.

Assuming that 95 per cent[2] of the inner wall only was involved in the thermal exchanges taking place during the experiment, which, considering the time factor, seemed a

1 Printed in Bulletin 153, Sept., 1919, American Institute of Mining and Metallurgical Engineers.

2 400 grams of water filled the calorimeter to within 3.1 c. m. of the top.

very reasonable assumption, we have for the water equivalent of the calorimeter and contents the following figures:

227.000 × .408 × .95 × .16	= 14.07	grams
3.86 × .90[1] × .16	.56	"
0.14 × .50	.07	"
Total	14.70	grams

Because of the uncertainty of the above assumption as to what proportion of the mass of the calorimeter was actually involved in the thermal exchanges in the calorimeter, the above figures were checked experimentally by the method of mixtures, as follows:

Two hundred (200.000) grams of water, previously cooled to about 20° below room temperature, was carefully weighed out, placed in the calorimeter, the calorimeter closed, and temperature readings taken at two-minute intervals. At the same time, two hundred (200.000) grams of water, previously warmed to a temperature of about 20° above room temperature, was placed in a thermos bottle and temperature readings taken at two-minute intervals alternately with the calorimeter temperatures.

After taking sufficient readings to establish a uniform rate of change of temperature, the warm water was poured into the calorimeter and constantly agitated by gentle stirring. Temperature observations at minute intervals were continued until a uniform temperature was established.

The following are the observations during one experimental determination:

Time	Calorimeter Reading (Microvolts)	Bottle Reading (Microvolts)	Room Temperature (in ° C.)
8:50		1619	23.3
8:51	200.2		
8:52		1617	
8:53	200.5		
8:54		1615	23.0
8:55	200.8		
8:56		1613	
8:57	201.1		
8:58		1611	22.8
8:59	201.4		
9:00		1609	

[1] 400 grams of water filled the calorimeter to within 3.1 c. m. of the top.

Time	Calorimeter Reading (Microvolts)	Bottle Reading (Microvolts)	Room Temperature (in ° C.)
9:01	201.7		
9:02		1607	22.75
9:02½	Mix		
9:03	885.6		
9:04	884.5		
9:05	883.6		
9:06	883		22.7
9:07	883		
9:08	883		

From the calorimeter readings prior to mixing, it appears that the calorimeter was warming at the rate of .3 microvolts per minute, while the water in the thermos bottle was cooling at the rate of 4 microvolts per minute, and the room temperature was falling at the rate of .04° C. per minute. At the instant of mixing the calorimeter temperature was 202.0 microvolts=5.211°, the temperature of the warm water in the thermos bottle 1607 microvolts=39.937°, and the room temperature, 22.75°. The temperature of the mixture, corrected for radiation, as shown on the chart, Fig. 14, is 886 microvolts=21.957°. The water equivalent "C" is, therefore,

$$C = \frac{(39.937 - 21.957) \times 200}{21.957 - 5.211} - 200 = 14.74 \text{ grams.}$$

Three other determinations were similarly made, with the following results:

(1) 14.74 (example above)
(2) 14.64
(3) 14.72
(4) 14.80

Average 14.725

This average value, as compared with the value calculated above, shows that the assumption made in the first case was very nearly exact. The above value for the water equivalent was further checked in determining the specific heat of the aluminum capsule as explained later.

(PART II *of this article will appear in the November-December issue of* ARMY ORDNANCE.)

The German Long-Range Gun

(*Continued from Page 100*)

April 11, 1919, states also that an engineer of the Skoda Works gave the length of the 210-millimeter liner as 30 meters with a 6-meter smooth-bore addition. A previous report dated November 22, 1918, says: "The P. W. had occasion to speak with a German colonel of artillery who knows well the details of the long-range gun which fired on Paris. The caliber of the gun is 210 millimeters and the length of the tube 34 meters. Three-fourths only of the length of the tube is rifled, to prevent excessive friction of the shell."

The tube which was approximately 140 calibers long, was rifled with 64 grooves having a constant pitch to the right of 4 degrees. This fact is known from the projectile which had two two rifled bands about it, therefore a constant pitch of rifling, and the number of grooves of the projectile was 64 with the pitch noted above. The 240-millimeter projectiles showed the same number of grooves as the 210; no guns were rebored to 260 millimeters to our knowledge. At least none of them were used in the bombardment. Probably the same number of grooves, 64, would have been used for this final caliber. We are still uncertain whether a series of hoops were shrunk on over the projecting portion of the 210-millimeter tube; presumably not, at least not over the entire length of the section beyond the 38-centimeter gun. It was inevitable that a gun 30 meters long would droop to a prohibitive extent, but apparently the Germans conducted their first trials at the proving ground without in any manner bracing the tube to hold it straight.

"The first few shots with full charges had been fired without incident, and we left the bombpoof in which we had taken refuge against possible accidents and stood in the open in order to watch the gun in action. The very next shot ripped off some fifteen meters from the projecting end of the 20-centimeter tube and hurled it vertically into the air to a great height. The gun had to go back to the factory. There it was not only repaired, but also stiffened, for the first gun had shown a perceptible sag and each shot set it into wild vibration." (7.)

This same characteristic of the gun was commented upon by an engineer of the Krupp Works, to Major G. M. Barnes of the Ordnance Department, during the past year. This engineer said that they had very carefully braced the gun to prevent any droop, that is, to keep it perfectly straight. There is another interesting comment on this in the report before referred to of Novem-

ber 26, 1918, from the Assistant Chief of Staff, A. E. F., to the Chief Ordnance Officer:

"On account of the enormous weight and great length of the tube, the latter curves slightly when the gun is laid. To remedy this a scaffolding was built to install a support above the tube by means of cables." (This was the report of a German colonel of artillery.)

It is probable that the tube was kept straight by steel rod trusses such as are commonly used to strengthen very tall flag masts. Three such braces, one on the top, and one on each side with the struts about midway or perhaps somewhat forward of the center would suffice. The full length of the original 38-centimeter gun would remain satisfactorily straight.

The 6-meter smooth-bore section attached to the end of the 30-meter rifled tube was probably a later development because they first attempted to use projectiles fitted with the usual copper rotating bands and unless there were two of these bands at some distance from each other such a projectile would be in effect a cone and would not fit in a cylinder. From the report quoted above with reference to the reason for not rifling the entire length of the gun it is perhaps natural to assume that on the failure of the copper-banded projectiles and the substitution of steel rifling on the projectile, additional velocity might be imparted to the projectile by the addition of this smooth-bore section. This may be the "new technical invention" referred to by Commander Kinzel in his description of the manner in which they solved the problem of attaining a range of 120 kilometers as ordered by General Ludendorff. The rifled projectile was a cylinder and would fit in the smooth-bore section and although gases might escape through the grooves of the projectile, some additional velocity might be imparted. This smooth-bore section was attached in the field. It was recessed and threaded to screw onto the rifled tube and each had collars shrunk and locked on their ends to furnish an additional rigid connection.

All information gathered from various sources indicates that the powder chamber was approximately 3 meters long and of a diameter equal to 210 millimeters plus twice the depth of the rifling. This chamber accommodated a metal powder case of its full length and the case was held in by the usual Krupp sliding wedge breech block with axial percussion firing mechanism. There is no reason why the original breech blocks of the 38-centimeter guns could not have been used and this was in all probability the case. There was no indication of a modification of this section of the three guns observed in the Skoda Works.

(PART II *of this article will appear in the November-December issue of* ARMY ORDNANCE.)

Major Robert S. Oberly

MAJOR ROBERT S. OBERLY, Chief of the Arsenal and Industrial Relations Section, Office of the Chief of Ordnance, died at Walter Reed General Hospital, September 4, 1923.

Born in Pennsylvania, September 26, 1885, he entered the Regular Army from civil life February 1, 1912, as a second lieutenant, Coast Artillery Corps. Later he was detailed to the Ordnance Department, and in January, 1917, was transferred to the Field Artillery.

During the World War Major Oberly held the rank of Lieutenant Colonel, Ordnance Department, and was assigned to responsible executive duties in the Office of the Chief of Ordnance and at the Aberdeen Proving Ground.

He was among the first contingent of officers who designed and constructed the Proving Ground and his work there was of the greatest importance in carrying out the Ordnance program during the war.

Of kindly manner, Major Oberly possessed those qualities of temperament and ability that combine to form the true officer and gentleman. He was an active member of the Army Ordnance Association and an ardent promoter of its interests. In his death the Association loses a charter member whose cooperation and interest were always most helpful.

Major Robert S. Oberly

Editorials

Another Milestone

THE Army Ordnance Association is on the threshold of another year of its life. Conceived amid the aftermath of the World War, an entirely new and untried adventure, it has survived the trials and struggles of the new-born and has succeeded for four years in preaching the doctrine of Industrial Preparedness throughout the land. Certainly this adventure, back in the days of 1919 when enthusiasm was high, well deserved the support of all patriotic citizens. And with each passing year the scope and influence has been broadened until today the Army Ordnance Association—probably the only exclusive exponent of Industrial Preparedness in the World—stands among the greatest civilian influences for the adequate industrial supply of the sinews of war.

The words of the Assistant Secretary of War, Mr. Davis, in his Chicago address, October 5, 1923, are well worth repetition here:

"With the aims and the objects of the Army Ordnance Association no true American can fail to be in heartfelt accord. Your example in devoting your time and effort to the furtherance of national defense is a wholesome counter-irritant to the spirit of unrest and radicalism that has come to us as a result of the World War and subsequent events. Civilization will be saved not by government, not by authority, but primarily by the action of sane public opinion. Such associations as yours are perhaps building even better than they know. The District Offices of the Ordnance Department, the Army Ordnance Association, and other official and semi-official activities which are functioning in support of our industrial effort in time of war, in the true sense of the word, belong to American industry rather than to American government. They represent the effort of American industry to forecast the future and prepare an organization to take care of itself. America's next war is going to be your war, and the effort which you are expending at the present time in furtherance of our defense plans will bear most abundant fruit if we are unfortunate enough to be involved in a war of major magnitude."

Thus the work goes on. For each of us there is a definite mission to help spread the doctrine to those who are unfamiliar with it: our effectiveness is in direct proportion to our strength. All patriotic citizens, particularly all executives and engineers upon whom our industry in peace and war depends, should be identified as members of the A. O. A. Surely all present and former Ordnance Officers and employees and all members of the Ordnance Officers Reserve Corps can in no more effective way further the interests of Ordnance than by membership in the Association.

"Pledged in a spirit of public service to effect industrial preparedness for war as being the nation's strongest guarantee of peace"—our cause is noble, our purpose high—let us continue with increased vigor in the interests of our American ideals.

Who's Who In This Issue

MR. HOWARD H. COOK, author of the article on The American Iron and Steel Institute is the assistant secretary of that organization. He has written a very interesting account of the group of distinguished men who will participate in the Fifth Annual Meeting of the Army Ordnance Association.

GENERAL GUY E. TRIPP, author of "Super Power as an Aid to National Defense," needs no introduction to the readers of ARMY ORDNANCE. He is a director of the Association and Chairman of the Westinghouse Electric and Manufacturing Company. General Tripp served as assistant to the Chief of Ordnance during the World War.

MAJOR HERMANN H. ZORNIG, at the time of the writing of his article on "Examination of Steel by Xray Spectrometer," was stationed at Watertown Arsenal and was engaged in research at the Massachusetts Institute of Technology. Major Zornig is now stationed at the Picatinny Arsenal.

MR. H. C. HALE, chief chemist at Picatinny Arsenal, writes on "High Explosive Shell Exudation"—a subject with which he is entirely familiar.

COLONEL F. E. WRIGHT, one of the foremost optical glass authorities of the country, has contributed a timely article on "The Scientist and Engineer as Reserve Officers." Colonel Wright was in charge of optical work for the Ordnance Department during the World War. He is now on the staff of the Geophysical Laboratory.

MAJOR H. A. NISLEY, of the Ordnance Department, author of "The Relation Between the Static and the Tensile Tests," presents a discussion of some very interesting data investigated while stationed at the Watertown Arsenal laboratories.

DR. CHARLES E. MUNROE, the nestor of explosive chemists of the United States, contributes some very enlightening deductions concerning wave distribution at the *Alum Chine* explosion. Dr. Munroe is a member of National Research Council and has had a long and useful career of public service.

COLONEL H. W. MILLER, formerly of the Artillery Division, Ordnance Department, is one of the best qualified engineers to discuss "The German Long-Range Gun." Colonel Miller is now a member of the faculty of the University of Michigan.

GENERAL RUGGLES, Chief of Manufacture, Office of the Chief of Ordnance, completes in this issue his very thorough discussion on "Artillery Design."

LIEUTENANT PHILIP SCHWARTZ, who, we trust, has broached a subject that will draw discussion in these pages from qualified authors, is stationed with the Coast Artillery Board at Fort Monroe, Virginia.

MR. WILLIAM F. GERMAN, author of "The Military Use of Commercial Explosives by the Germans," is an engineer on the staff of the DuPont Company.

MAJOR A. M. PRENTISS, of the Chemical Warfare Service, contributes Part I of his work on "Specific Heat and Thermal Diffusivities of Certain Explosives."

Mrs. Creedy C. Sheppard

HARDLY a year ago ARMY ORDNANCE had the pleasure of announcing to its readers the marriage of its Associate Editor—Miss Morrie Bodley Morris—to Colonel Creedy C. Sheppard, formerly of the Ordnance Department, during the war Chief of the Small Arms and Machine Gun Division, Office of the Chief Ordnance Officer, American Expeditionary Forces in France and later Assistant to the Chief of Ordnance in Washington. Today, with hundreds of her friends, we are mourning her untimely death as a result of complications arising after the birth of a baby boy, Philip Lee Sheppard.

Soon after the United States entered the World War there came to the Ordnance Office a slender little girl whose frail body belied the brave heart within. Determined to do her bit to help win the war, she offered her services in any capacity and they were promptly availed of. Her ability was soon recognized and she was quickly promoted from one position of responsibility to another. When the War Council was organized she was asked for by name for assignment as confidential secretary and performed these exacting duties with tireless zeal and marked intelligence. When the War Council was dissolved she returned to the Ordnance Department and assisted in handling secret cablegrams and confidential courier letters from France, which required the personal attention of the Chief of Ordnance. She also devoted considerable time to Military Intelligence work, in which her keen mind found a sphere of greatest usefulness to the Government in balking attemps at graft, thwarting sabotage and organizing counter-espionage.

After the war ended she eagerly seized upon industrial preparedness on the part of the United States as the most available means for preventing a repetition of the waste of money and lives occasioned by the World War. When the formation of the Army Ordnance Association was under consideration she entered with enthusiasm upon the preliminary work and gave of her health and strength so unsparingly that she suffered a nervous breakdown from which she gamely recovered, however, in time to participate in getting out the initial number of ARMY ORDNANCE. In the early days of the Association it was a continual struggle to keep it alive from day to day, but in the face of every possible discouragement, she never wavered in her faith as to the ultimate success of this hitherto unattempted venture. To her painstaking care ARMY ORDNANCE owed its freedom from typographical errors, to her sense of values its presentable appearance, and to her facility of expression much of its literary style. Our printers and engravers have said repeatedly that our manuscript and material for illustrations came to them in better shape than any in their whole experience, a tribute to her intelligent planning that saved the Association many hundreds of dollars in "author's alterations," for which costly and unnecessary item, no charge has ever been marked up against ARMY ORDNANCE. Amateur editors are probably never very welcome visitors at any printer's shop, but "Miss Morris" was a shining exception. From printer's devil up, they respected her judgment, admired her ability, and strove to outdo each other in producing work that would warrant her eagerly sought "O.K./M.B.M."

We knew her in times "when everything went dead wrong," when it seemed an utter impossibility to get out the magazine presentably and *on time*. But her calm, clear mind met all difficulties with serene confidence and her unalterable determination to finish what she started inspired us all to redoubled efforts. Even after her marriage she helped "get out the magazine," at an expenditure of vital energy, it has turned out, she could ill afford.

And now she sleeps at Arlington among the soldier dead—stricken down in the hour of her greatest glory that found fulfillment in motherhood.

She gave her life—and we know she gave it gladly—that another might live. To her devoted husband and their infant son, and to her bereaved mother, we extend our heartfelt sympathy.—J. L. W.

Professional Notes

Ammunition Division

THE RECENT BOMBING TESTS ON BATTLESHIPS

ON September 5, 1923, the Army Air Service carried out a most interesting maneuver in which the battleships *New Jersey* and *Virginia* were bombed and sent to the bottom.

These battleships were rendered surplus by the "Limi-

The "New Jersey" Shattered But Afloat

tation of Armaments Conference," and as the resulting treaties required that they be scrapped the opportunity was offered to conduct an "Aerial Battle Practice." The two ships were quite similar in character. Both were completed about 1904. Some of their principal dimensions were:

Length between perpendiculars	435 feet
Breadth	76 feet
Draft	23 ft. 9 ins.
Displacement	14,980 tons
Main armor belt	about 12 inches

The area of the main deck, the physical target, was about 26 000 square feet. The area included within lines 30 feet distant from the ships' sides and parallel thereto was about 56,000 suare feet, and the area bounded by lines parallel to and 50 feet distant from the ships' sides was about 79,000 square feet.

The two ships were anchored near the Diamond Shoals Lightship about 25 miles off Cape Hatteras.

The transport *St. Mihiel* with the Assistant Secretary of War Davis; General Pershing; Major General Patrick, Chief, Air Service; Major General Coe, Chief of Coast Artillery; Rear Admiral Shoemaker, U. S. N.; and a number of distinguished civilians, attachés of many foreign countries, and many Army and Navy officers arrived on the scene early Tuesday morning. Several Navy destroyers and Coast Artillery mine planters were on hand to patrol the area.

Two dirigibles appeared in the sky about 8.30 a. m. and shortly afterwards a number of scout planes arrived led by Brigadier General William Mitchell, Assistant Chief of Air Service. From that time on scout planes were continually hovering about the scene.

Shortly thereafter the first flight of five Martin bombers appeared high in the air. These planes, each carrying four six-hundred-pound bombs, had started from Langley Field, about 175 miles distant. They were flying at an altitude of between 10,000 and 11,000 feet and at once began the attack upon the *New Jersey*.

Of the twenty bombs dropped, two made direct hits upon the deck. This attested the accuracy of the bombers at high altitudes. One of these hits was near the side of the ship and apparently did little damage. The second struck well aft and a large section of the deck was torn up, but there was no other visible effect. A second attack was made upon the *New Jersey* about an hour later by seven Martin bombers, each carrying one two-thousand-pound bomb. These planes started from a temporary bombing field located at Cape Hatteras for the occasion. They were aided by one machine that carried four six-hundred-pound bombs.

This attack was made from an altitude of about 6,000 feet. While no direct hits were made, the ship took on a slight list.

The planes then shifted the attack to the *Virginia*. The first and only flight against the *Virginia* consisted of seven

Bombing the "Virginia"

Martin bombers, each carrying two eleven-hundred-pound bombs. The attack was launched from an altitude of about 3 000 feet.

Of the fourteen bombs dropped, two made direct hits and several were apparently quite close. The effect of the first direct hit was most striking. A dense black smoke

enveloped the entire ship and when it cleared away both cage masts, all funnels, and practically all davits were down. A large hole was blown out of one side of the ship almost to the water line. This bomb apparently pierced the main deck and detonated between decks with most destructive effect. Shortly after the last bomb of this attack had detonated, the *Virginia* began to capsize and within a few minutes later she had disappeared from view. In the meantime the *New Jersey* still remained afloat, no increase in the list having taken place.

A third attack by seven Martin bombers, each carrying one two-thousand-pound bomb, was launched upon her in the afternoon. None of these bombs had any visible effect.

A fourth and final attack was made by two Martin bombers each carrying two eleven-hundred-pound bombs. The third bomb dropped in this attack from an altitude of 4,000 feet struck fairly on the deck and detonated down near the bottom of the ship. This was a fatal hit and the *New Jersey* had disappeared from view within ten minutes.

Between the first and second attacks on the *New Jersey* a specially fitted airplane gave a demonstration of laying a smoke screen. A curtain of smoke was dropped between the *St. Mihiel* and the targets. A second curtain of smoke laid nearer the target drifted over and completely obscured the battleship.

Several important facts were demonstrated in the exercises. Among these were:

The high altitude bombing and its accuracy;

The long flight from Langley Field of the planes carrying four six-hundred-pound bombs, and their return to a temporary field on the coast line;

The establishment by the Air Service of a temporary field on the coast line where planes could fuel-up, take on bombs and start out to attack;

The laying of a smoke screen by a plane that could encircle the fastest moving ship and thus aid the bombers to close in with less risk of damage from anti-aircraft guns;

The terrific damage done by high explosive bombs bursting between decks;

Finally, it can be said that the exercise was a great success and that many points in addition to those mentioned above will be studied with resulting gain to both the Army and Navy.

Watervliet Arsenal.

EFFECT OF "WHIP" ON THE TRAVEL OF THE PROJECTILE IN THE BORE

Recently 14" Gun number eighteen (18) Model 1910 M1 was sent to this arsenal for relining. In this particular gun a new form of rifling was used; the gun itself being built-up from the liner out. This method of assembly is opposite to that which is used when a gun is relined, for here of necessity the new liner is assembled to the already built-up gun. New rifling was designed for these guns with a view to reducing the radial pressure exerted by the rotating band and other causes. In the past the rifling in certain guns has shown signs of excessive radial pressure. This new rifling presents almost a radial surface on the driving side of the land so that the radial pressure effect should be reduced. The theory supporting this design will not be touched upon in this article.

A brief description of this new rifling is given in connection with the line of thought to be advanced later. The twist is right hand, uniform, and one turn in twenty-five calibers. There are one hundred and thirty-six grooves, the grooves being 0.1734" wide and 0.12" deep. The lands are .15" wide. The driving side is almost radial and a slight fillet is used at the bottom of the driving side with a larger fillet at the bottom of the driving side (See Fig. 1). From this sketch it will be noted that there is not much difference between the width of the land and the width of the groove.

Upon examination at this arsenal when the above-mentioned gun was returned for relining, several irregularities were noted which in general were not uncommon, namely, erosion, heat cracks, choke or contraction in the bore, coppering and wear. It was also noted that the liner had rotated approximately .570" in a clockwise direction looking from the muzzle end, and had protruded .727" at

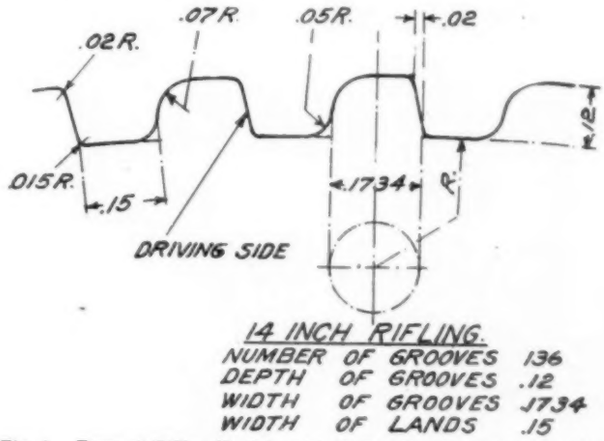


Fig. 1. Form of Rifling Used in 14-inch Gun No. 18, Model 1910 M I

the muzzle end and .061" at the breech end. It is not intended here to discuss all of these irregularities but a short discussion will be given to advance ideas in connection with the excessive wear on this gun.

Looking from the muzzle end it was noted that between 12.30 and 3.30 o'clock the lands were worn considerably. The pictures of the gutta percha imprints shown in Fig. 2 indicate this very clearly. The pictures of the gutta percha imprints were made at fixed distances throughout the gun. From them it was noted that the wear at the muzzle extended into the gun for a distance of 130" and that this wear gradually decreased. At the muzzle end it showed that two-thirds (2/3) of the land had been worn away while at a distance of 150" from the muzzle the wear seemed to disappear. In addition to this gradual variation in wear it was found that it followed the twist of the rifling. The figures inserted below show that the wear is decidedly greater along the twist than straight down the bore.

Extract from Tabulated Readings Taken in Bore of 14" Gun No. 18 Model 1910 M1

Reading down bore	Reading down groove	Distance from muzzle
.047	.047	0
.056	.053	10"
.058	.060	20"
.073	.063	30"
.085	.060	40"
.093	.070	50"
.108	.080	60"
.110	.080	70"
.113	.095	80"
.116	.094	90"
.118	.100	100"
.121	.098	110"
.122	.100	120"
.122	.108	130"

The complete proof reports of the gun show that it underwent more or less severe firing tests. A total of one hundred and eighty-three (183) rounds were fired at Aberdeen Proving Ground between the dates of July 27, 1921, and July 24, 1922. The purpose of these tests was to secure general and special information. The maximum powder pressure recorded was forty-one thousand (41,000)

pounds per square inch and the minimum powder pressure was eleven thousand (11,000) pounds per square inch. As this is within the allowable limits it can not be reasonably assumed that the abnormal wear on the lands could be due to the effect of powder pressure. The test reports show that some trouble was encountered with the projectiles due to loose fuzes and defective windshields. Some rounds show that the windshields came off and were seen to fall to the ground several hundred yards from the firing point. It is, however, not believed that even the probability of a loose or broken shield in the bore would have caused this

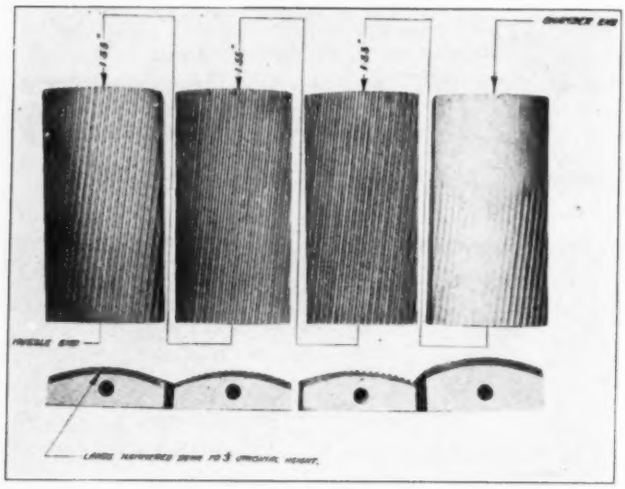


Fig. 2. 4.7-inch Gun Carriage, Model 1921 E

very gradual increase in wear. This serious defect in all probability would have shown up in a more definite manner starting with a decided deformation at the point when the windshield interfered with the travel of the projectile.

It is believed by the writer that this wear is due to a combination of two results, "jump" and "whip." "Jump" is here taken to mean the vertical movement of the muzzle which begins practically at the instant recoil starts. This occurs in all guns. "Whip" is explained here as the vibration set up in the gun due to the suddenly applied powder pressure. It is contended that the bore expands under this suddenly applied pressure and that there is another point forward of this expanded section that must necessarily contract. It is then reasonable to assume that this expansion and contraction sets up a series of expansions and contractions that travel the length of the bore, no doubt at a higher velocity than that of the projectile. In other words, a wave motion is set up in the gun. This first series of wave motions will then be naturally followed by other series of waves, but of less intensity until finally the gun comes to rest.

The projectile starting from rest accelerates in velocity as it travels down the bore. The natural tendency of the projectile is to rectify itself and travel along the axis of the bore. It is assumed that the 14" gun may be considered as rigid enough to the rear of the trunnions so that it will not distort due to the above-mentioned jump, so that whatever effect this wave motion may have on the course of the projectile up to the trunnions may be considered as the only abnormal force acting. Forward of the trunnions it is again contended that the "jump" does cause a flecture in the gun, so that here the two abnormal forces may influence the travel of the projectile. Attention is called to the fact that the unusual condition of wear occurred entirely forward of the trunnions. The rotary speed of the projectile is constantly increasing in its travel together with its increasing linear velocity. It is not difficult to believe that a body weighing sixteen hundred pounds rotating at a very high speed might be changed from its path by the influence of these abnormal forces, nor is it even so difficult to believe that the combination of the two forces might deviate the projectile from its true path. Now if this projectile is thrown off its path even so slightly, the bourrelet is naturally thrown considerably nearer the top of the lands. Originally there is only .015" clearance between the bourrelet and the top of the land. Once deviating from its path the very fact that the rotary speed of the projectile is increasing will tend to change it still more from its true path, and the bourrelet will come in contact with the top of the lands. The effect of the "jump" will be principally in a vertical plane. The vibratory wave effect travels concentrically with the bore. It is almost guesswork to say what the resultant effect of these two forces will be, but it will appear to be in a vertical plane,

An effort has been made to use only actual results obtained at Aberdeen Proving Ground and from the arsenal inspection of this 14" gun to illustrate the "whip" theory advanced. The uniform protrusion of the "A" tube at the muzzle end and the fact that the bearing shoe at the breech end had to be faced off so that the block could be closed can be cited as evidence of the crawling in both directions of the metal. It is not supposed that the "crests" and the "troughs" of these waves were so great as to break the shrinkage at any point. Even though the shrinkage is not broken there must be a crawling and necessarily an elongation of the tube. It is contended that the very fact that a wave motion is set up will tend to cause muzzle and breech protrusion. This movement is assisted naturally by the flow of the gases, and the pull of the rapidly rotating projectile. The linera, or the "A" tube, has only one shoulder and that is near the breech end so that the actual movement of the tube starts in both directions from this shoulder. The movement towards the muzzle end is naturally the greater.

Summing up the evidence in hand, it is believed that the abnormal wear in this 14" gun is due to the fact that the projectile was thrown off its true course by a combination of "jump" and "whip." The "jump" effect would be in a vertical plane while the "whip" effect would set in a wave motion and travel concentrically with the bore. At some point in the bore it is probable that the two forces would act together and that this result changed the true course of the projectile. Once changed, the bourrelet of the projectile continues to approach the top of the lands until finally it begins to cause the wear.

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Reserve Corps Notes

The following have accepted commissions in the Ordnance Officers' Reserve Corps since the last issue of ARMY ORDNANCE:

Majors:

Campbell, Jeremiah
Green, Samuel G.
Reichner, Louis I.

Captains:

Cecil, Roy L.
Beilin, Arthur I.
Bobb, Clarence H.
Holmes, Kenneth L.
McHugh, Keith S.
Renn, Paul R.
Thomas, Earl M.

1st Lieutenants:

Brown, Theron H., Jr.
Drake, Richard A., Jr.
Ellis, Alden Q.
Resler, John C.
Stark, Henry M.

2d Lieutenants:

Arnold, Charles F.
Bertsch, Fred W.
Brashear, Alvan V.
Brown, Carlton E.
Brown, John E.
Brown, Seymour W.
Bryden, Colby W.
Burroughs, Kenneth C.
Burt, Robert V.
Churchill, Charles H.
Dodson, Willard F.
Duerr, Karl B.
Ford, Raymond O.
Fox, William M.
Grant, Raylor B.
Haller, Karl R.
Henderson, Wayne G.
Jacobson, David
Kramer, Harold B.
Leewitz, George J.
Liddle, Harold W.
McLarty, Gordon
Maxon, Bruce E.
Mehlhope, Lincoln E.
Parker, Ralph J.
Pratt, Lewis S.
Prothero, Harry T.
Randall, Joseph H.
Reed, Daniel H.
Rogers, Donald A.
Schneidewind, Richard
Sharp, Robert K.
Sharp, Russell H.
Sherbrook, Roscoe E.
Shuster, William W.
Tabaknek, Mendel
Ten Eyck, Harold R.
Titus, Buel F.
Van Ness, Russell T.
Van Sickle, Roswell C.
Weiner, Louis
Willits, Charles W.

A training course for Ordnance Reserve Officers of the B. A. Group assigned to Ordnance districts will be held at Rock Island Arsenal, Frankford Arsenal and Springfield Armory from November 12th to 24th, 1923. The course will be limited to Captains and 1st Lieutenants this year, due to limited funds available for pay and allowances.

The course of instruction will be in two sections. Captains will be trained in the "Chief Inspectors Course" which will cover the following:

Duties of Ordnance representative at commercial plants, including inspection, finance, storage, shipment, contracts, specifications, vouchers, property accounting, cost accounting, etc.

Lieutenants will be given the "Inspectors Course," which will cover instruction to familiarize officers with duties and responsibilities of inspectors. Two days will be spent in instructing lieutenants in the duties of Chief Inspectors.

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